Project 1680

WILDLIFE RESOURCES OF THE ROCKY MOUNTAIN ARSENAL ADAMS COUNTY, COLORADO

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13. ABSTRACT (Maximum 200 words)

THIS REPORT PRESENTS THE RESULTS OF WILDLIFE INVESTIGATIONS CONDUCTED AT RMA DURING 1986 AND 1987 ON BEHALF ON SHELL OIL COMPANY. THE MAJOR OBJECTIVES OF THE STUDY WERE TO:

1. DOCUMENT THE DISTRIBUTION AND ABUNDANCE OF TERRESTRIAL VERTEBRATES ACROSS RMA
2. EVALUATE WILDLIFE USE IN RELATION TO HABITAT TYPES AND CONTAMINATION SOURCES
3. COMPARE WILDLIFE USE AT RMA WITH SELECTED OFFSITE AREAS, INCLUDING BUCKLEY AIR FIELD AND PLAINS CONSERVATION DENTER.

SECTIONS OF THE REPORT INCLUDE INFORMATION ON:

1. ECOLOGICAL SETTING AT RMA AND THE SURROUNDING AREA
2. FIELD METHODS EMPLOYED
3. RESULTS AND ONSITE-OFFSITE COMPARISONS.

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1.0 INTRODUCTION

1.1 PURPOSE

This report presents the results of wildlife investigations conducted at the Rocky Mountain Arsenal (RMA) during 1986 and 1987 by Morrison-Knudsen Environmental Services, Inc. (MKE). The studies were conducted on behalf of Shell Oil Company (Shell) through the law firm of Holme Roberts and Owen. Much of the information collected during the MKE field program was used by the Army (and its contractor, Hunter/ESE) in preparing the Biota Remedial Investigation (RI) report for RMA (ESE 1989). The purpose of this report is to provide greater detail on the Shell/MKE studies than was appropriate for the RI and to present some information not incorporated into that document.

The major objectives of the wildlife investigations were to (1) document the distribution and relative abundance of terrestrial vertebrates across the RMA, (2) evaluate wildlife use at RMA in relation to habitat types and contamination sources, and (3) compare wildlife use at RMA with selected offsite areas. The studies involved the collection of quantitative data supplemented by extensive qualitative observations.

To help make this report more readable, species are referred to in the text by common name. Scientific names are provided in the species lists (Appendix A).

1.2 ARSENAL OVERVIEW

The Rocky Mountain Arsenal is an Army installation covering about 70 square kilometers (27 square miles) in southern Adams County, Colorado, about 16 km (9 mi) northeast of Denver (Figure 1-1). Before the Arsenal was established, the area was used primarily for rangeland and dryland agriculture, mostly as small

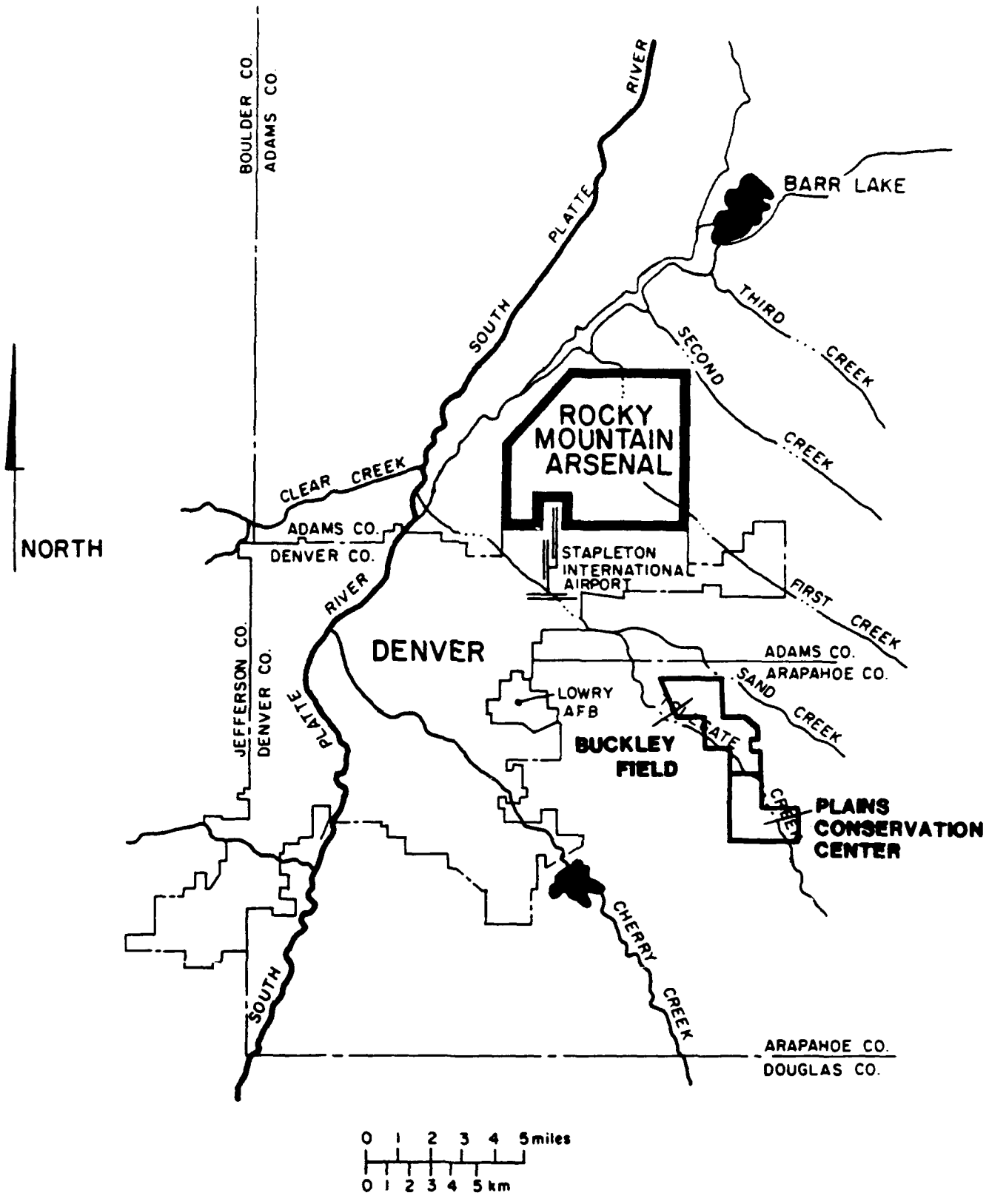


FIGURE 1-1

LOCATION MAP

farms and ranches. This land use still dominates areas to the north and east of RMA. The small town of Derby was in the vicinity of the area now occupied by the South Lakes.

The RMA was originally established in 1942 as a World War II facility for the manufacture of chemical and incendiary munitions. After the war, the Army continued to produce, store, and demilitarize chemical agents at the Arsenal. Later, several of the facilities in the South Plants were leased to private chemical manufacturing companies. Starting in 1947, Colorado Fuel and Iron (CF&I) manufactured chlorinated benzenes and DDT. During that same year, Julius Hyman and Company (Hyman) began production of a variety of pesticides. Hyman leased land that had been covered by the CF&I lease in 1950. In May 1952, Shell aquired Hyman and continued manufacturing pesticides until 1982.

At present, activity at the Arsenal is limited to three main categories: (1) administration, maintenance, and security; (2) technical investigations related to cleanup of the site; and (3) interim response actions to remedy or stabilize various "hot spots."

2.0 ECOLOGICAL SETTING

2.1 PHYSIOGRAPHY AND TOPOGRAPHY

The region in which RMA is located has been referred to by Thornbury (1965) and Hunt (1967) as the High Plains Section of the Great Plains Province. The High Plains grade abruptly into the Southern Rocky Mountain Province approximately 23 km west of the Arsenal.

The topography of the Arsenal is gently rolling with low hills and intervening basins. Elevations range from approximately 1,500 meters (m) in a closed depression along the northwestern boundary to about 1,625 m in the southeastern corner. Other high areas include "Rattlesnake Hill" (about 1,615 m) near the center of the site, and "Henderson Hill" (about 1,600 m) near the northeastern corner.

2.2 GEOLOGY AND SOILS

Surficial deposits on the RMA consist of stabilized eolian sand and alluvium composed of sand, silt, and gravel. This surface veneer is generally less than 15 m thick over most of the Arsenal. Greater thicknesses of alluvium overlie paleochannels eroded into the bedrock surface. The alluvium also gradually thickens north and northwest of the site, toward the South Platte River. The Cretaceous Denver Formation, consisting of 120-190 m of interbedded shale and weakly indurated lenticular sandstone, underlies the surficial deposits across the entire Arsenal. The alluvium and the Denver Formation are the two aquifers of primary importance at RMA.

Soils of the RMA include three general groupings: (1) clayey soils on nearly level upland surfaces, especially in the northern portion of the site; (2) sandy eolian soils on more rolling upland surfaces, especially in the southern portion of

the site; and (3) loamy and sandy stratified alluvial soils on the floodplains and low terraces of major drainages. The soils generally are deep and well drained. Most show clay and, to a lesser extent, lime enrichment in the subsoil.

2.3 CLIMATE

The climate of the region is sunny and semi-arid and generally lacks prolonged periods of very cold or very hot weather. The region averages about 30 days with highs above 32°C (90°F) and 150 days with lows below 0°C (32°F) per year; the average growing season is 180 days. Mean maximum and minimum temperatures are about 5°C (41°F) and -11°C (12°F) for January, and 29°C (85°F) and 13°C (55°F) for July.

Mean annual precipitation of the region is about 39 centimeters (15.5 inches). The wettest season is spring (March - May), which receives about 35 percent of the yearly total as wet snow or rain. Precipitation gradually declines through the summer as rainfall becomes more scattered but occasionally intense, then decreases further during fall and winter. The winter season (December - February) receives only about 11 percent of the yearly total precipitation, in the form of fairly frequent but very dry snowfalls. Relative humidities are generally low, with monthly averages of about 50-60 percent throughout the year and numerous days below 10 percent.

2.4 VEGETATION

The original, pre-settlement vegetation of the RMA probably was dominated by various native grassland communities interspersed with stands of shrubs or yucca, and with narrow belts of cottonwoods and willows along drainages. After settlement, most of the area was converted to agricultural uses such as grain and hay production and livestock grazing. These activities resulted in extensive removal or degradation of the native plant cover.

The existing vegetation of the RMA is dominated by three weedy plant communities or vegetation types. These three--referred to by MKE as the weedy forb, cheatgrass/weedy forb, and cheatgrass/perennial grass vegetation types--together comprise about 65 percent of the total land area at the Arsenal. All three of these weedy community types have resulted from disturbance, such as related to agriculture (plowing, heavy grazing) or the construction and operation of the Arsenal.

In addition to the three weedy vegetation types are stands dominated by crested wheatgrass, an introduced species widely planted in the 1930s and 1940s to rehabilitate disturbed or overgrazed rangeland. Crested wheatgrass covers about 15 percent of the Arsenal. The remainder of the site includes some areas of native grassland with varying amounts of yucca and shrubs, scattered thickets of locust or wild plum, upland groves of deciduous trees, riparian woodlands, cattail marshes, and a few ornamental plantings.

2.5 SURFACE WATER

Surface runoff on the Arsenal flows generally northwestward toward the South Platte River, which roughly parallels the northwestern boundary at a distance of about 3.2 km. The largest and most important surface drainage on the Arsenal is First Creek, which has a total length onsite of 9.4 km. First Creek originates in Arapahoe County, Colorado, 32 km east of Denver. In dry years, the flow of First Creek on the Arsenal is continuous only during the spring and following major storms. In general, however, it may be characterized as a fairly persistent intermittent stream. The persistence of flow is evidenced by well-developed hydrophytic and phreatophytic vegetation along much of its length.

The only natural body of standing water at RMA is North Bog Pond, located just west of First Creek. The pond is not entirely natural because it is significantly augmented by excess water from the nearby North Boundary Containment/Treatment System. However, the surrounding bog--actually a small marsh fed by a seep--is natural and pre-dates the Arsenal.

Artificial bodies of water at RMA include a series of four impoundments known collectively as the South Lakes or Lower Lakes (Lake Mary, Lake Ladora, Lower Derby Lake, and Upper Derby Lake), plus three smaller impoundments. The smaller impoundments are Rod and Gun Club Pond, located in a natural depression south of Lower Derby Lake; Toxic Storage Yard Pond, along First Creek in the east-central part of the site; and Havana Pond, which collects runoff from residential and commercial/industrial areas south of the Arsenal.

2.6 WILDLIFE

The RMA is located within the High Plains Section of the North Temperate Grassland Biome as described by Shelford (1963). Consequently, the fauna of the region is dominated by species adapted to prairie, steppe, and savannah communities. The diversity of wildlife near the western edge of the plains is greatly increased by the presence of habitats other than grasslands. These include conifers and mountain brush on mesas extending eastward from the foothills, wetlands and adjacent cottonwood/willow woodlands along drainages and lakes, shade trees or shelter belts around ranches and farms, and ornamental plantings in parks and residential neighborhoods.

Major components of the regional fauna are summarized in the following subsections.

2.6.1 Mammals

The mammalian fauna of the region is variable, depending primarily upon vegetation and land use. Rangelands often support desert cottontails, black-tailed jackrabbits, thirteen-lined ground squirrels, and black-tailed prairie dogs, although these species have been intensively controlled in many areas. Pronghorn occur locally in rangelands that have not been overgrazed. Badgers and coyotes are the most widespread carnivores in these habitats. Swift foxes and spotted ground squirrels were formerly abundant in sandy rangelands, but their numbers have been greatly reduced.

Riparian woodlands provide habitat for eastern cottontails, white-tailed deer, red foxes, raccoons, and (in some areas) fox squirrels. Near the mountains, riparian woodlands also attract mule deer and gray foxes. Wetlands may support beaver and muskrats.

Species diversity and abundance tend to be greatly reduced where intensive agriculture is the dominant land use. Even in these areas, however, some species are quite successful. Thirteen-lined ground squirrels frequently reach pest proportions in plowed land, and shelter belts provide cover for rabbits, raccoons, striped skunks, coyotes, and foxes. Fox squirrels have benefited from plantings of deciduous trees in parks and residential areas.

2.2.6 Birds

The regional avifauna also reflects the diversity of habitats within the plains ecosystem. Prairie rangelands are used primarily by ground-nesting songbirds such as western meadowlarks, horned larks, lark buntings, savannah sparrows, vesper sparrows, and grasshopper sparrows. McCown's and chestnut-collared longspurs also nest in the region, although

the Arsenal is near the southern edge of their range. Ferruginous hawks, northern harriers, and short-eared owls nest on the ground in open grasslands, while burrowing owls nest in abandoned prairie dog burrows. Large trees provide nesting habitat for a variety of raptors, including ferruginous hawks, red-tailed hawks, golden eagles, American kestrels, great horned owls, and long-eared owls. Rimrocks also are used for nesting by most of these species, plus prairie falcons.

Scattered trees provide nesting habitat for small species such as eastern kingbirds, western kingbirds, black-billed magpies, loggerhead shrikes, and lark sparrows. These species are also attracted to riparian woodlands and shelter belts, as are northern flickers, downy woodpeckers, red-headed woodpeckers, American robins, yellow warblers, blue grosbeaks, indigo buntings, northern orioles, and American goldfinches. Near the mountains, wooded areas attract additional species, including MacGillivray warblers, black-headed grosbeaks, rufous-sided towhees, lazuli buntings, and lesser goldfinches.

Marshes and wet meadows support a distinctive avifauna, typically dominated by common yellow throats, red-winged blackbirds, yellow-headed blackbirds, and song sparrows. Wetlands also provide nesting habitat for grebes, American coots, common snipe, Virginia and sora rails, Canada geese, and a variety of ducks. Great blue herons and black-crowned night-herons feed in wetlands and nest in large trees such as riparian cottonwoods.

2.6.3 Reptiles and Amphibians

The herpetofauna of the region is rather depauperate, probably due in large part to the relatively long, cold winters. Bullsnakes, western hognose snakes, yellow-bellied racers, milk snakes, and western rattlesnakes are widespread in native upland habitats, and the bullsnake may also be abundant in agricultural

areas. Lowland habitats attract plains and common garter snakes, while northern watersnakes occur in some permanent bodies of water.

Lizards are less conspicuous than snakes in the region. Lesser earless lizards, short-horned lizards, many-lined skinks, and six-lined racerunners occupy a variety of prairie habitats, with the latter two generally preferring lusher vegetation. Eastern fence lizards also occur, but typically only in rocky or wooded terrain, or around buildings.

Snapping turtles and painted turtles occupy permanent bodies of water, while western box turtles may be found in grasslands. None of these species is abundant in the region.

Amphibians present in the region include northern leopard frogs and bullfrogs in permanent bodies of water, and plains spadefoot toads, Woodhouse's toads, Great Plains toads, and northern chorus frogs in a wide range of wetland habitats and temporary ponds. Tiger salamanders breed in both permanent and temporary ponds, but the adults may be found far from water.

3.0 METHODS

This section describes the field methods employed during wildlife investigations at RMA. An effort was made to use widely accepted methods that would provide information on the occurrence, distribution, and relative abundance of the vertebrate groups selected for study. The level of detail varied among the seasons and the groups of organisms. Studies ranged from detailed quantitative analyses to semiquantitative indices and qualitative observations. More intensive studies were used for species of particular ecological, regulatory, or economic importance, and those considered especially useful as indicators of contamination and habitat quality. Qualitative information was collected to provide a comprehensive view of ecosystem structure and function, and to corroborate the major patterns evidenced by the quantitative investigations.

The following subsections describe field methods used for the various groups of terrestrial vertebrates at RMA and the offsite comparison areas.

3.1 COYOTES, FOXES, AND OTHER CARNIVORES

Coyotes and foxes are relatively long-lived, occupy specific home ranges, and are near the top of the food web. Also, they feed on a variety of species and spend much of their time in dens dug into the soil. Therefore, their patterns of abundance and distribution could be useful in evaluating whether soil contamination has had an observable effect at the population level.

Although many techniques are available for estimating relative abundance of carnivorous mammals, the scent-station survey (Linhart and Knowlton 1975, as modified by Roughton and Sweeny 1982), was selected because it was specifically designed for coyotes and other canids.

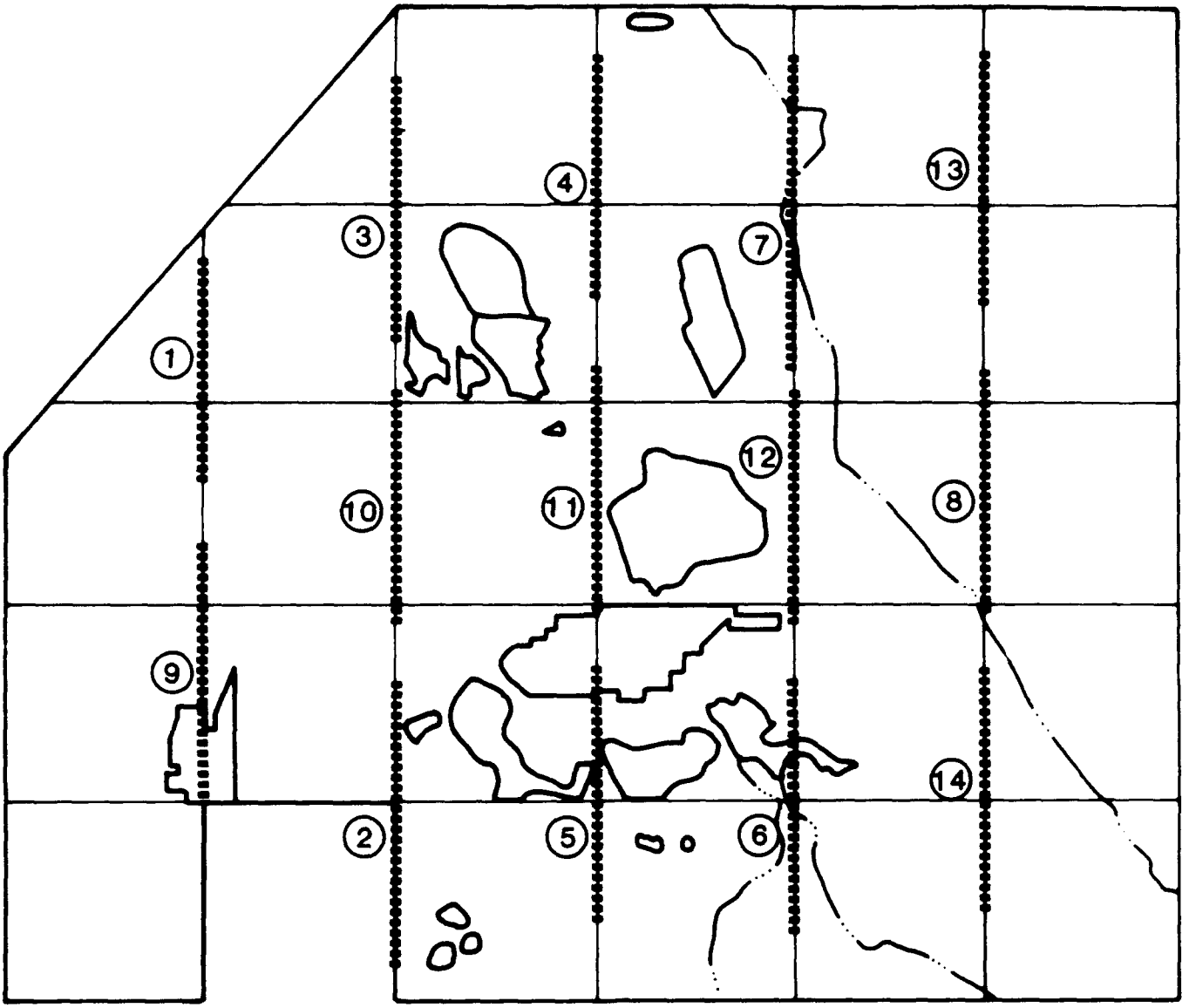
Sampling for coyotes and foxes was conducted at fourteen locations on the RMA (Figure 3-1) in late October and mid-November 1986. Each sampling location consisted of a transect of five scent stations spaced at 0.3-mi intervals. The scent station was a 3-ft diameter circle of sifted soil with an olfactory or scent attractant placed in the center. The attractant was formulated by the U.S. Fish and Wildlife Service (FWS) specifically for censusing coyotes. Animals attracted to the scent leave their tracks in the sifted soil. Presence or absence of tracks ("visits") were recorded for each species at each station.

The fourteen transects were systematically arrayed (Cochran 1977) to provide representative sampling across the RMA. Stations were located near the edges of roads, alternating to either side. The index of coyote abundance equals the number of visits divided by the number of stations, multiplied by 1000.

Smaller carnivores (e.g., badgers, raccoons, and skunks) were studied qualitatively by identifying tracks encountered after a snow or at the scent stations (the FWS attractant is moderately effective for these other species) and recording opportunistic observations during the course of other field activities.

3.2 DEER

Deer studies involved estimates of herd size and distribution on the RMA, and comparisons with selected offsite areas. Criteria for selecting offsite areas were that they have habitats similar to RMA, be located within the general vicinity, and support sizable populations of deer. The offsite locations were specifically recommended by the Colorado Division of Wildlife (CDOW). Three methods were used for deer investigations: nighttime roadside surveys, aerial counts, and fecal pellet counts. These are described below.



Rocky Mountain Arsenal

Figure 3-1.

Coyote and Fox Transects

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3.2.1 Roadside Surveys

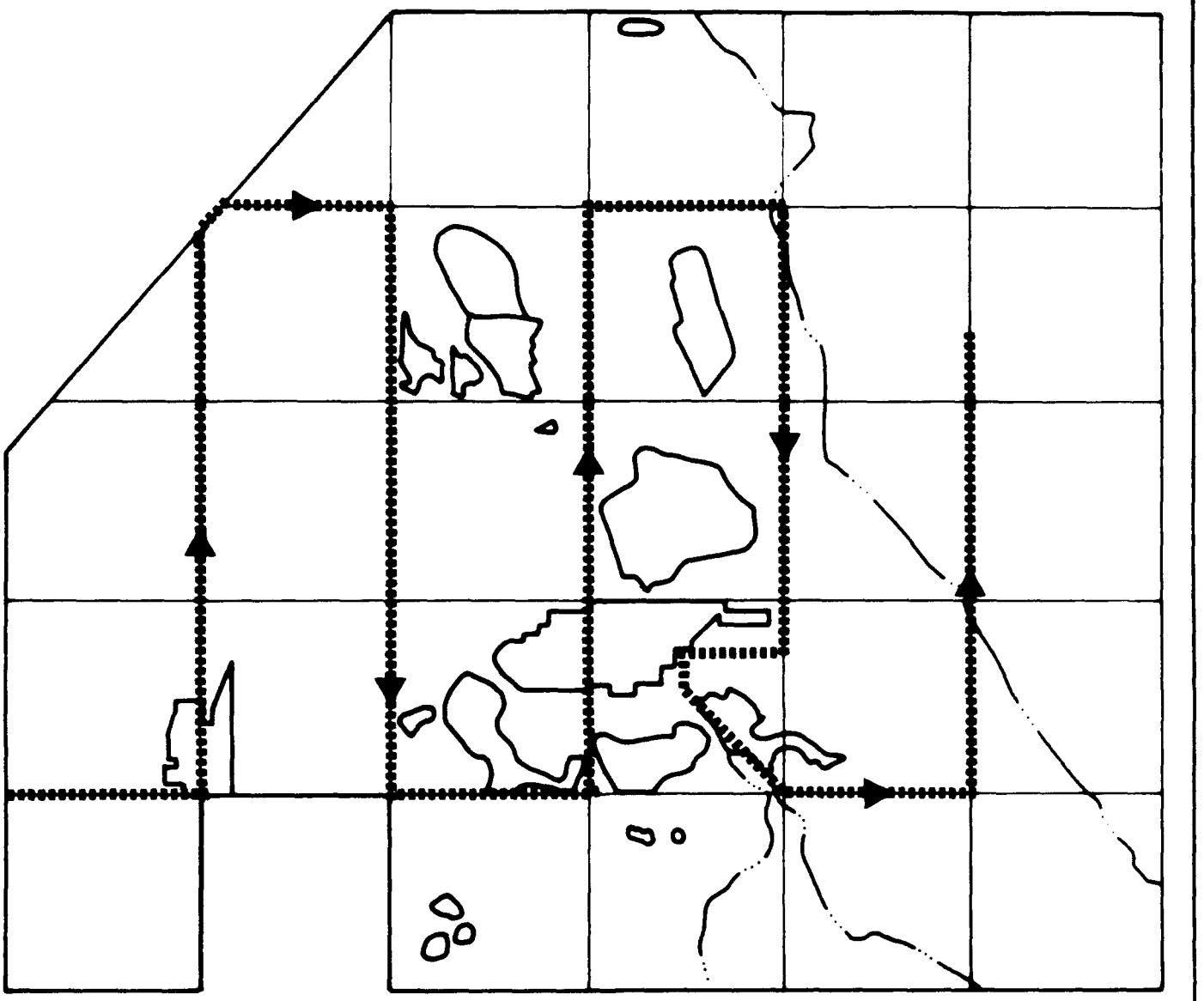
Roadside surveys are commonly used for estimating the relative abundance of deer (Mackie 1970, Woolf and Harder 1979, Hesselton and Hesselton 1982). This method is well suited for the RMA, because section roads traverse nearly all habitats and cover the site uniformly.

Five roadside surveys were performed on the RMA (Figure 3-2) and four offsite near Horse Creek Reservoir (Figure 3-3). A 20-mi route was traveled on the RMA; only a 14.4-mi route was possible at the Horse Creek site. The offsite route was discontinuous because of discontinuous habitat.

Counts were conducted in the early evening, from one-half hour to 2 hours after sunset, between late April and mid-June 1986. Two observers, including the driver, conducted all counts. Vehicle speed was approximately 10 mph.

3.2.2 Total Counts

Estimates of the number of mule deer and white-tailed deer on the RMA were made by conducting five counts from a vehicle during the winter of 1986-87. All counts were performed during daylight hours by two observers, including the driver. Double counting was minimized by recording all observations on maps carried in the vehicle and by avoiding unnecessary stops and other delays. Some of the counts were performed during times of snow cover for improved visibility. The total counts differed from the roadside counts in that an attempt was made to cover as much of the site as possible, rather than adhering to a standardized route.



Rocky Mountain Arsenal

Figure 3-2.

Deer and Rabbit Survey Route

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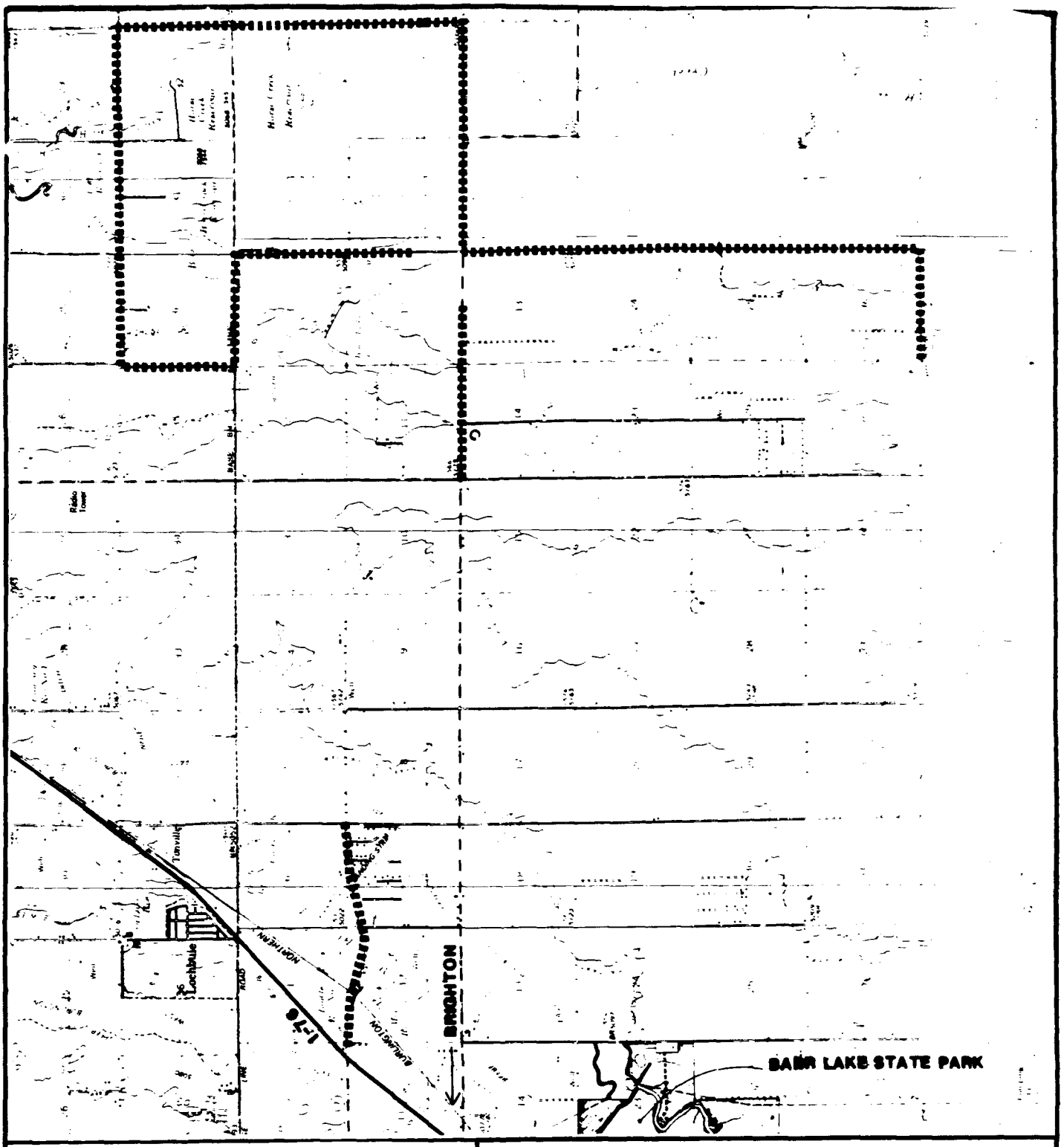

Figure 3-3.

Deer and Rabbit Survey Route , Offsite
(Adams Co.)

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A MORRISON KNUDSEN COMPANY

3.2.3 Fecal Pellet Counts

Fecal pellet counts were conducted at 111 locations on the RMA and at 54 offsite locations. The offsite locations were split evenly between Buckley Air National Guard Base (Buckley) and the Plains Conservation Center (PCC). These sampling locations coincided with plots established for a coordinated study of vegetation and songbirds, described later (see Figures 3-10 and 3-11). The pellet counts were performed by counting all distinct pellet groups within two parallel strip transects (each 1 m x 100 m) positioned approximately 4 m to either side of a centerline through the larger (100 m x 100 m) songbird plots. Counts were mostly conducted between August and November 1986. The songbird plots were used because of their thorough coverage of the Arsenal as well as the detailed vegetation data obtained at these sites.

3.3 COTTONTAILS AND JACKRABBITS

Cottontails and jackrabbits ("rabbits") were considered important because they live in close contact with the soil, are major prey species for a variety of larger predators, and represent a potential exposure pathway to humans. Two methods were used for rabbit studies: roadside counts and fecal pellet counts.

3.3.1 Roadside Counts

The roadside counts used for cottontails and jackrabbits were similar to those described previously for deer, and both studies were conducted simultaneously along the same routes (Figures 3-2 and 3-3). As described for deer, these counts occurred between late April and mid-June 1986, and from approximately one-half hour to 2 hours after sunset. The transect width for rabbit

counts was limited to the width of the headlight beam. Similar procedures have been described by Lord (1959, 1961), Kline (1965), and Chapman et al. (1982).

3.3.2 Fecal Pellet Counts

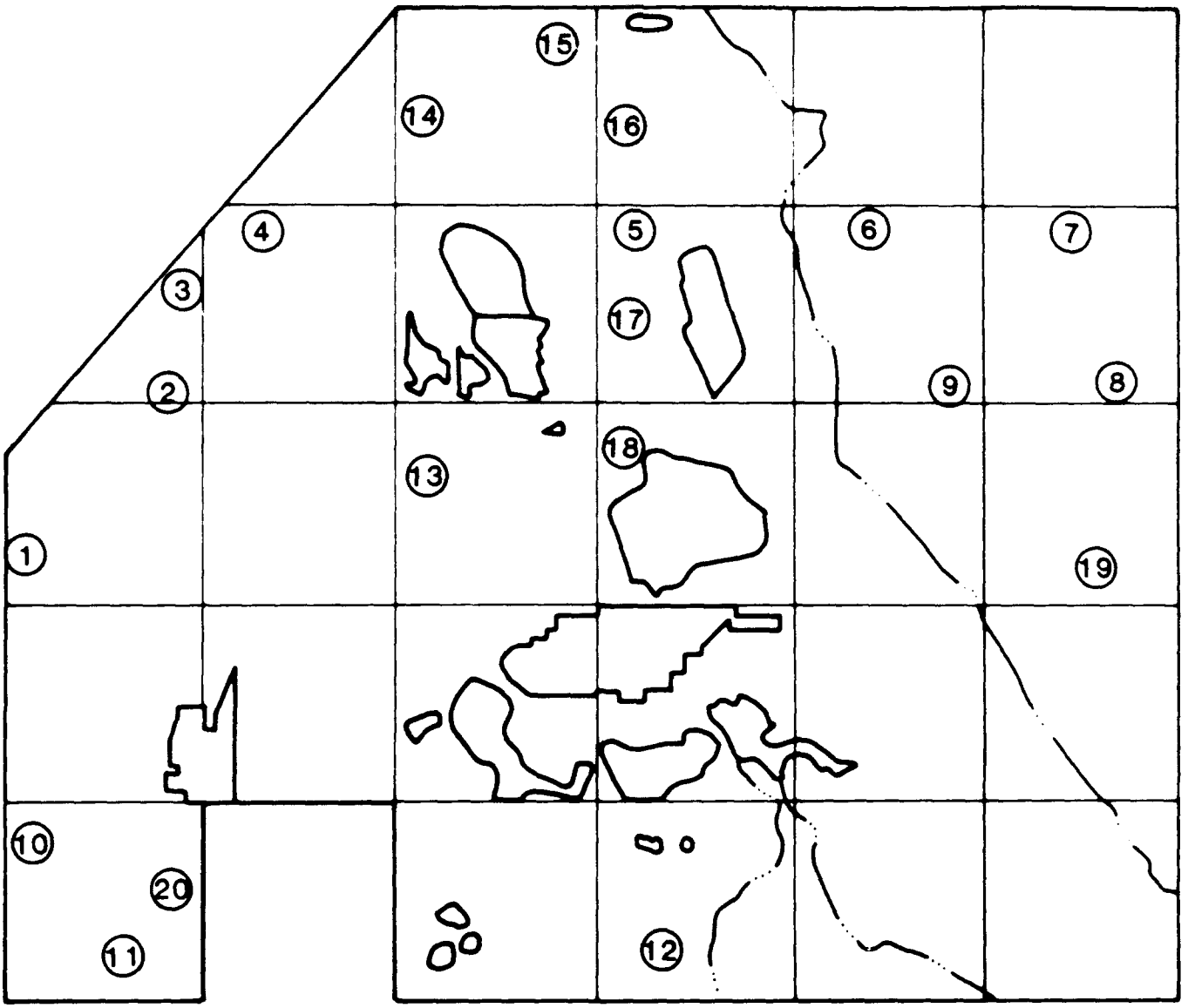
Rabbit fecal pellets were counted concurrently with counts of deer pellets, and within the same plots. However, because cottontails and jackrabbits tend not to deposit their fecal pellets in groups, presence or absence of pellets was tallied for contiguous 2-m segments along each 1 m x 100 m transect. Pellets of any age were counted, and no attempt was made to distinguish between pellets of different species.

3.4 PRAIRIE DOGS

Black-tailed prairie dogs, like cottontails and jackrabbits, were considered to be of special importance because they live in intimate contact with the soil and are a major prey species for various avian and mammalian predators. In addition, being widespread on the RMA they were well suited for evaluating population structure relative to potential soil contamination.

Field work was performed in 1986 and 1987. In 1986, sampling occurred June 14-18, with twenty counts conducted on the RMA, four at Buckley, and two at PCC. In 1987, sampling occurred May 14-27, with twenty counts again conducted on the RMA (at the same locations as 1986), ten at Buckley, and ten at PCC (Figures 3-4 and 3-5). The counts were designed to provide data on population structure (i.e., age-class composition) from onsite and offsite locations.

Age-class estimates were made by observing prairie dogs from a vehicle (using binoculars or spotting scope) and classifying clearly visible individuals as either adult or juvenile. Main roads within the three study areas were traveled, and



Note: Circled numbers represent sampling locations.

Rocky Mountain Arsenal

Figure 3-4.

Prairie Dog Sampling Locations

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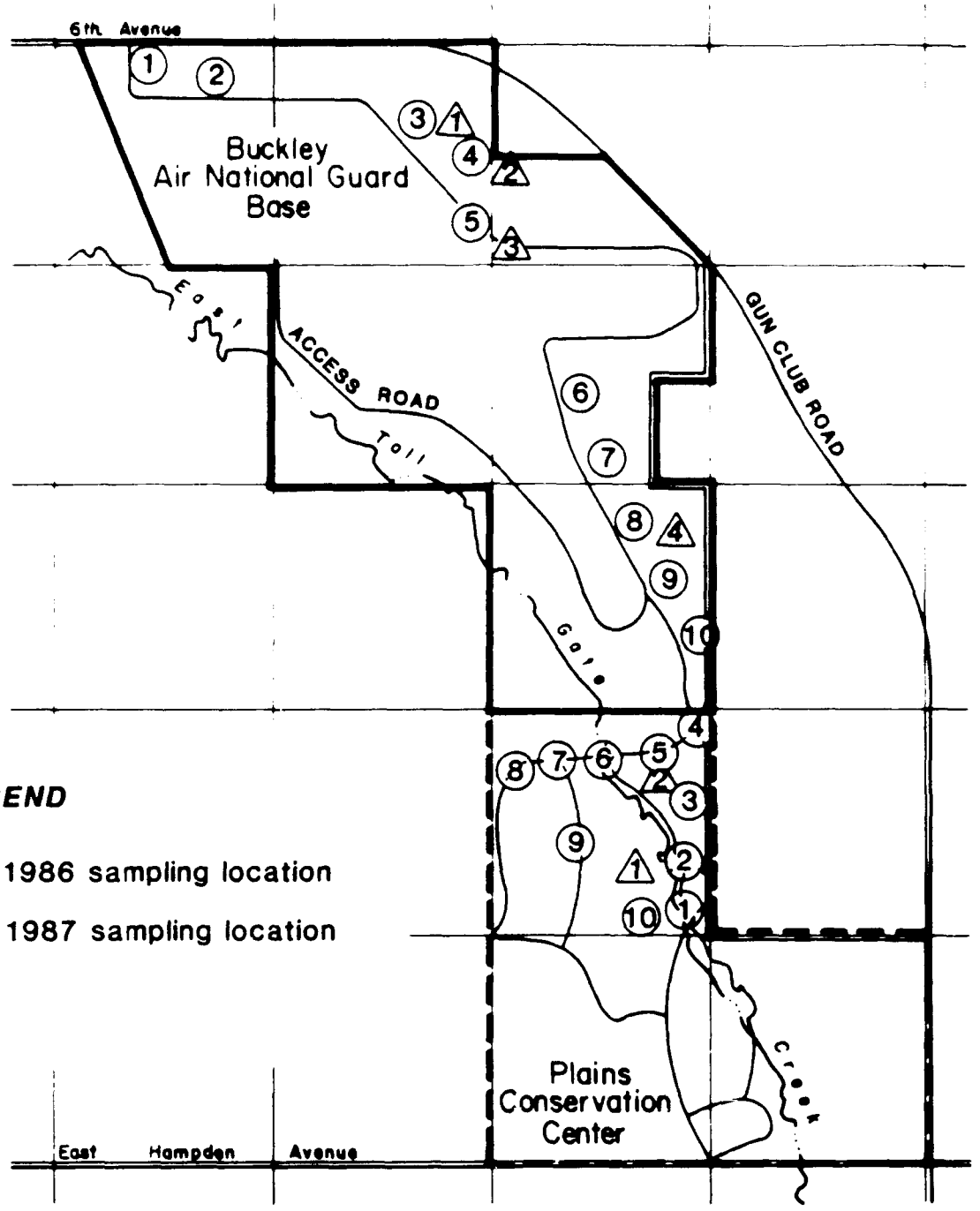
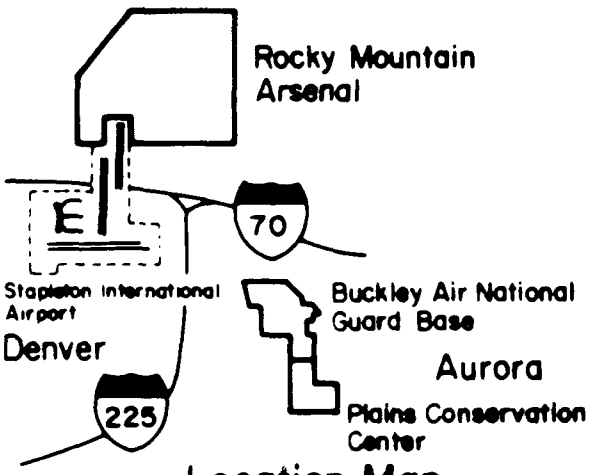




Buckley Air National Guard Base and Plains Conservation Center

Figure 3-5.

Prairie Dog Sampling Locations

MORRISON-KNUDSEN ENGINEERS, INC.

observation points were chosen when at least thirty animals could be seen within 50 m of the vehicle. Age-class estimates were performed after waiting 5 minutes (to let the prairie dogs resume normal activities). Observation points were spaced a minimum of 0.5 mi on the RMA; on Buckley and PCC, observation points were more closely spaced (as close as 0.1 mi) because of the limited extent of prairie dog colonies.

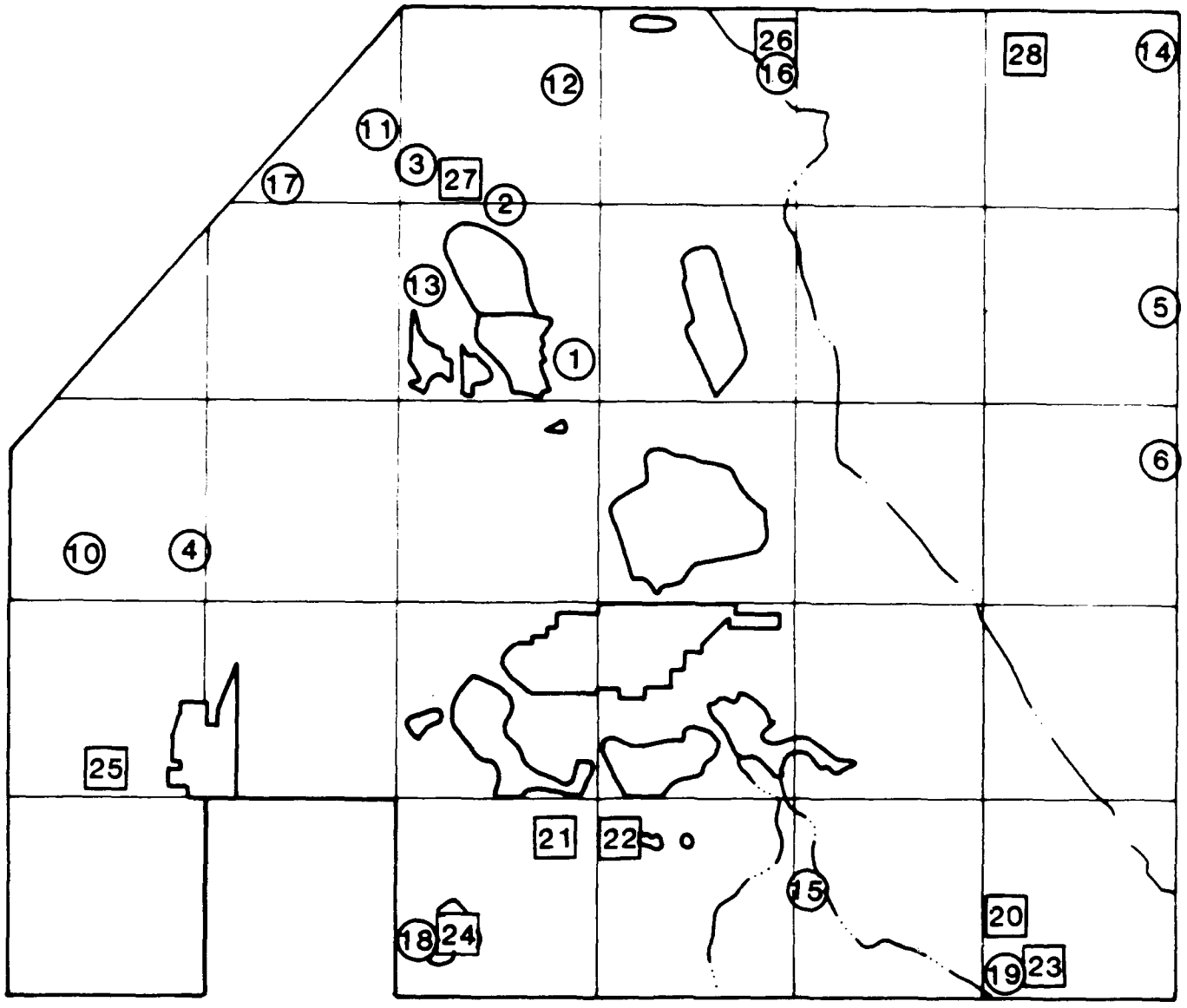
Additional information on prairie dog distribution, burrow density, and population size was collected by Hunter/ESE. Results of these studies are presented in the Biota RI (ESE 1989).

3.5 SMALL MAMMALS

These species, which include mice, voles, and shrews, were surveyed primarily by live-trapping in November 1986 and June 1987. Emphasis was placed on documenting species occurrence and comparing use among different habitat types.

Trapping in 1986 was conducted at sixteen locations on the RMA (Figure 3-6) and at three locations on Buckley (Figure 3-7), with a total effort of 3,060 trap-nights (a trap-night is one trap set for one night). Each location was an area approximately 50 m x 300 m, positioned well within a distinct habitat type. Trapping effort on the RMA was distributed among eight habitat types as follows (number of trap-nights in parentheses): cheatgrass (720), crested wheatgrass (720), native perennial grass (360), tall weedy forbs (360), riparian (90), short weedy forbs (90), yucca (90), and sand sagebrush (90). Trapping effort at Buckley was 180 trap-nights each in cheatgrass, crested wheatgrass, and native perennial grass.

At most of the locations, the sampling grid consisted of six parallel transects arranged 10 m apart. Each transect consisted of ten traps placed at 10-m intervals. The grid of sixty traps



LEGEND

(2) 1986 sampling location

[20] 1987 sampling location

Rocky Mountain Arsenal

Figure 3-6.

Small Mammal Trapping Locations

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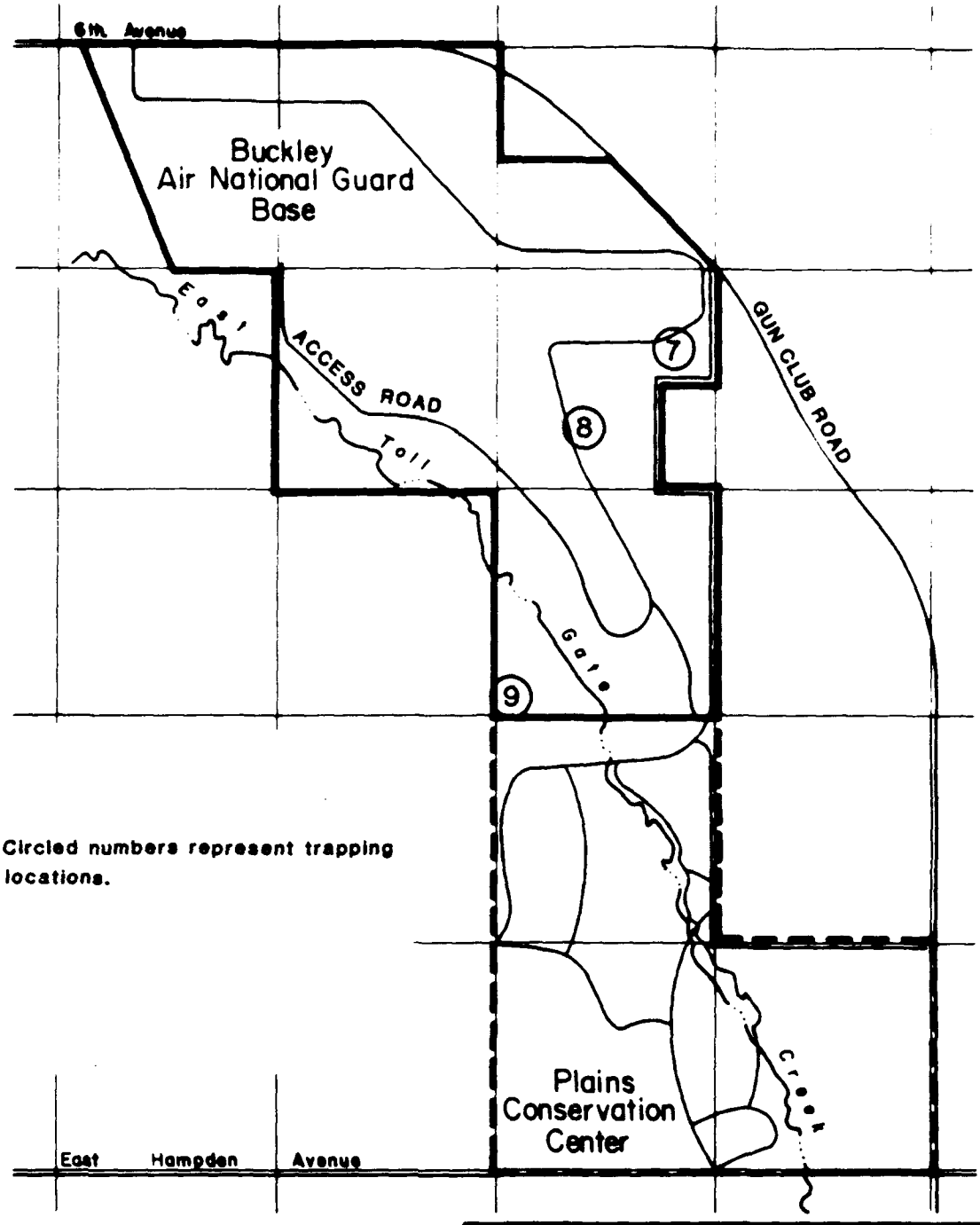
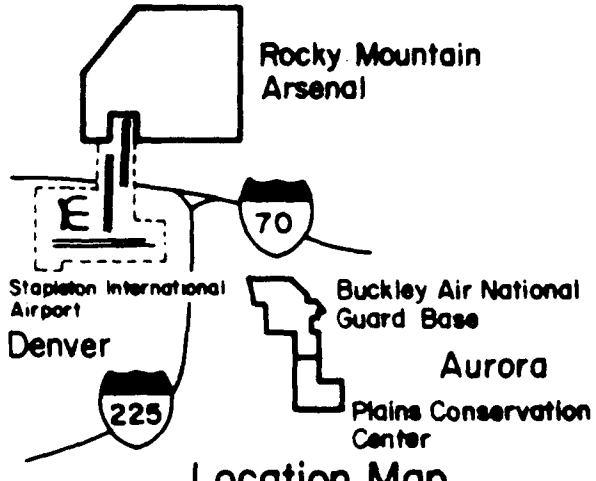


Note: Circled numbers represent trapping locations.



Location Map

Buckley Air National Guard Base and Plains Conservation Center

Figure 3-7.

Small Mammal Trapping Locations

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was repositioned on each of three nights by moving the transects ahead 10 m. The rationale for moving traps to a new position each night was to achieve statistically independent samples (capture probability uninfluenced by previous captures) and to sample a larger area (Stoecker 1982). Small habitats on RMA and the three locations at Buckley were too small to be sampled using the above procedure and therefore were sampled merely by setting out 45 traps at 10-m intervals for two nights.

All trapping in 1986 occurred in November. A small number of snaptraps were used to supplement the livetraps. Bait for all traps consisted of a mixture of peanut butter, bacon grease, and corn meal.

Sampling in 1987 was restricted to the RMA (Figure 3-6) and was distributed among habitat types as follows (number of trap-nights in parentheses): cattails (200), streamside grass/forbs (200), weedy forbs (200), sand sagebrush (200), yucca (200), juncus swales (150), locust thickets (150), rabbitbrush (100), cottonwoods (100), and plum thickets (75).

All trapping in 1987 occurred during the first week of June. Traps were placed in what was subjectively judged to be suitable habitat for capturing additional species. Random, statistically independent samples were not necessary because the objective was species identification, not a quantitative comparison. Snaptraps were used in potential shrew habitat; livetraps were used otherwise. Bait was the same as that used in 1986.

3.6 OTHER MAMMALS

3.6.1 Muskrats

Muskrat surveys were designed to provide an index of muskrat abundance along the principal bodies of water on the RMA, using the "house count" method (Davis and Winstead 1980, Perry 1982).

Counts were performed on April 22-23, 1986, by enumerating all houses (bank dens as well as surface dens constructed of vegetation) in wetland vegetation along the shorelines of North Bog Pond, Lake Mary, Lake Ladora, Lower Derby Lake, the Rod and Gun Club Pond, and First Creek. Havana Pond was not surveyed because it does not provide suitable muskrat habitat. The areal extent of wetland sampled was later estimated using air-photo interpretation. Only houses believed to be in current use were counted, as evidenced by recently gnawed vegetation, the presence of scat or tracks, or fresh excavations.

3.6.2 Pocket Gophers

Pocket gopher surveys involved counting excavations (mounds, eskers) along the transects used for deer pellet surveys. To minimize counting multiple mounds belonging to a single burrow system, only mounds separated by at least 5 m were tallied (Howard 1961, Chase et al. 1982).

3.7 SMALL BIRDS

As used in this report, the term "small birds" includes all passerines (perching birds) as well as woodpeckers, swifts, and hummingbirds. During all the small bird investigations, information was routinely recorded concerning temperature, wind speed and direction, relative humidity, and cloud cover. This information was monitored primarily to ensure that all counts were conducted under favorable conditions.

Studies of small birds included quantitative surveys in winter and the spring nesting season, and qualitative surveys during all four seasons. The qualitative (unstructured) surveys were performed in order to obtain a more thorough listing of bird species occurring at the RMA and to provide additional insight

into habitat use. The spring and winter quantitative surveys employed different methods, as described in the following subsections.

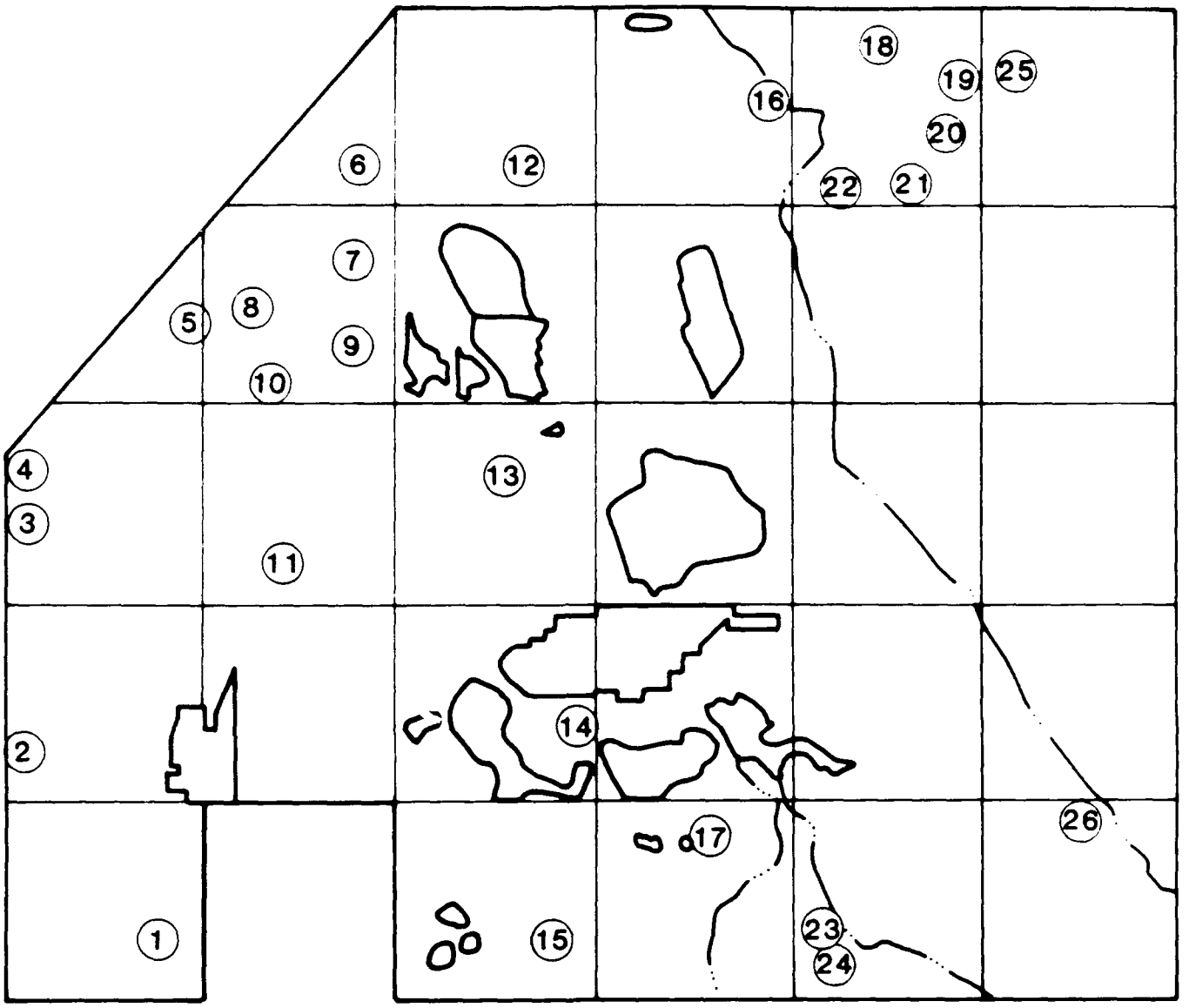
3.7.1 Winter Counts

Winter birds tend to occur in irregularly distributed, wide-ranging flocks. Surveys were therefore conducted at a relatively coarse scale, and the resultant data were used primarily to discern major patterns. On the RMA, winter surveys were intended to document whether all of the expected winter residents were present, and to look for gross differences in abundance and distribution across the site.

Sampling occurred along 26 transects on the RMA (Figure 3-8) and along 5 transects each at Buckley and PCC (Figure 3-9). Methods were based upon those described by Nilsson (1974), Emlen (1977),and Mikol (1980), with slight modifications. Individual transects were generally 500 m long, although shorter transects (200 m to 350 m) were sometimes required because of limited habitat. Counts were conducted by slowly walking along the transects and recording all birds seen or heard within 75 m. Three counts were conducted along each transect between mid-February and mid-March 1986. All counts were performed by the same investigator, and always between 0645 and 1100 hours (MST).

3.7.2 Spring (Breeding) Counts

Grassland songbirds were selected for intensive sampling during the breeding season because they are conspicuous and readily counted, consume a variety of plant and invertebrate prey, and feed almost entirely within small territories during the nesting season. Their distribution and abundance are not particularly good indicators of direct contamination effects because they are



Note: Circled numbers represent transect locations.

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Figure 3-8.

Winter Songbird Transect Locations

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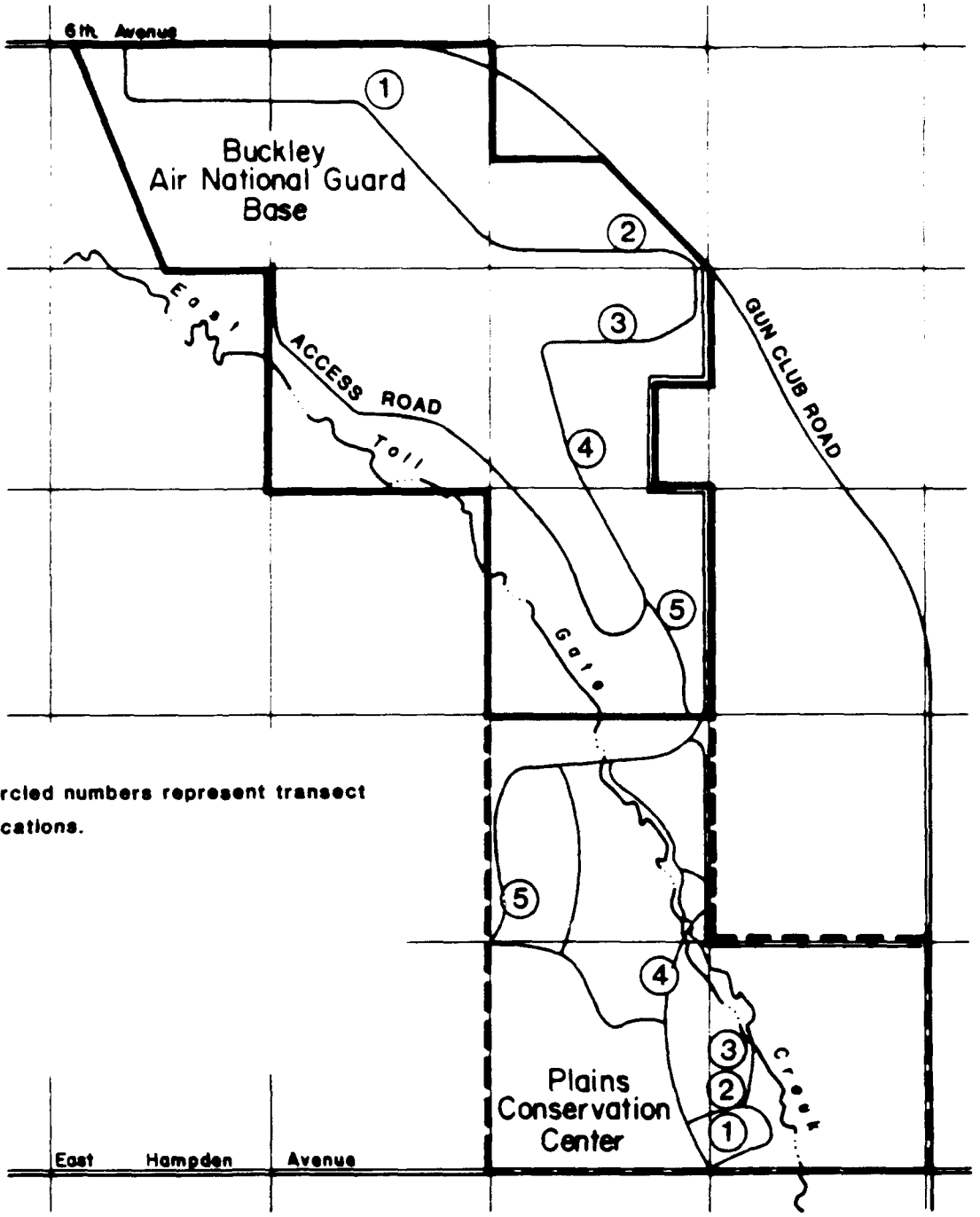
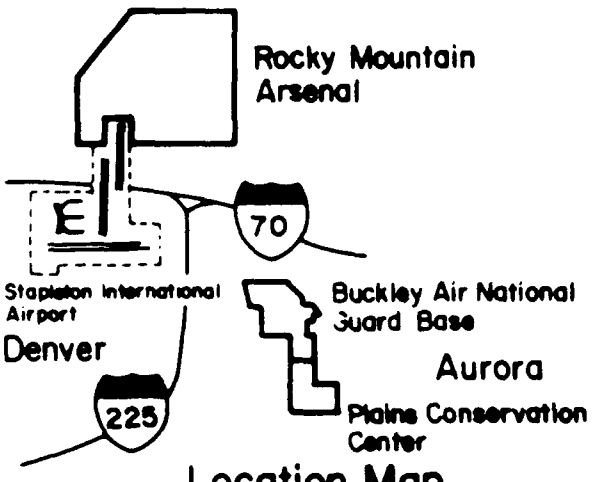


Note: Circled numbers represent transect locations.



Location Map

Buckley Air National Guard Base and Plains Conservation Center

Figure 3-9.

Winter Songbird Transect Locations

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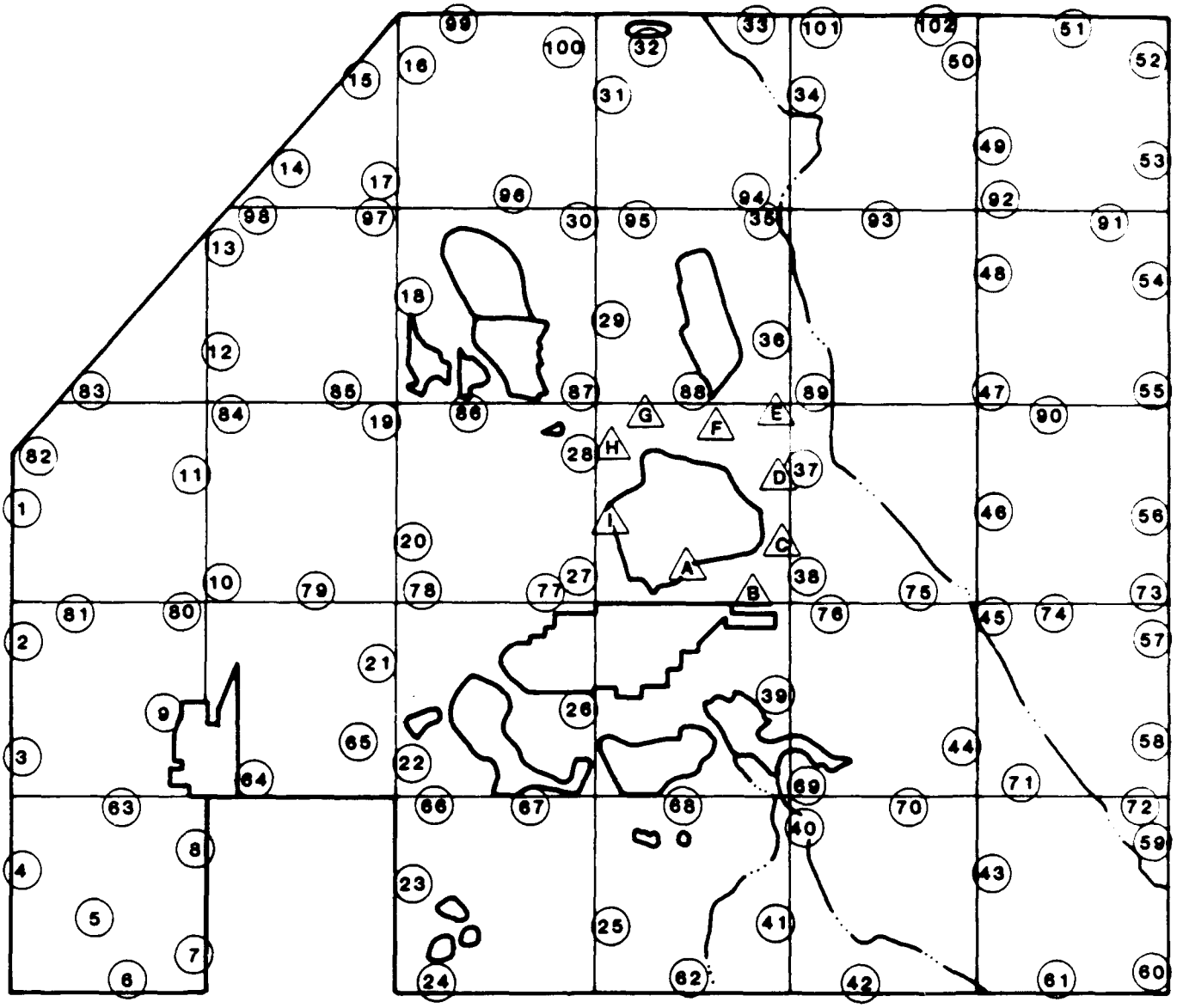
short-lived and migratory. However, they are good indicators of habitat quality, which may in turn be affected by contamination (i.e., indirect contamination effects).

Spring breeding counts were conducted within 111 plots on the RMA (Figure 3-10), and within 27 plots each at Buckley and PCC (Figure 3-11), for a total of 165 plots. Plots were 100 m x 100 m (1 ha) and were positioned at predetermined, regularly spaced intervals beginning at a random starting point (a systematic random design; see Cochran 1977). Plots on the RMA were positioned at 0.6-mi intervals along east-west and north-south section roads, alternating to either side of the roads. In order to sample more intensively in Section 36, nine plots were located at 0.4-mi intervals along the four section road segments surrounding it. Section 36 includes Basin A and is considered one of the most contaminated areas of the Arsenal. Due to limited space, plots at Buckley and PCC were positioned at 0.2-mi intervals. In cases where a sampling location was unsuitable (e.g., a building or severe disturbance), the plot was moved a predetermined direction and distance.

Birds were censused by counting the number of singing males heard within the plots during 4 minutes. Observers typically counted from the mid-point along the side of the plot closest to the road to minimize disturbing singing birds within the plot. Three observers, working singly, visited all plots once. The separate observers visited the plots in different sequences to avoid time-of-day influences. Counts were performed between late May and mid-June 1986, mostly between sunrise and 1100 hours MDT.

Vegetation sampling was conducted in all 165 bird plots to provide data for habitat characterization. Shrub density estimates were obtained by counting all shrubs within two 1-m x 50-m belt transects. Percent areal coverage of grasses, forbs, total vegetation, and bare soil, as well as the number of



Note: Plots also used for fecal pellet and pocket gopher counts.

LEGEND

(6) Plots located at 0.6 mi intervals.

(A) Plots located at 0.4 mi intervals.

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Figure 3-10.

Breeding Songbird Plot Locations

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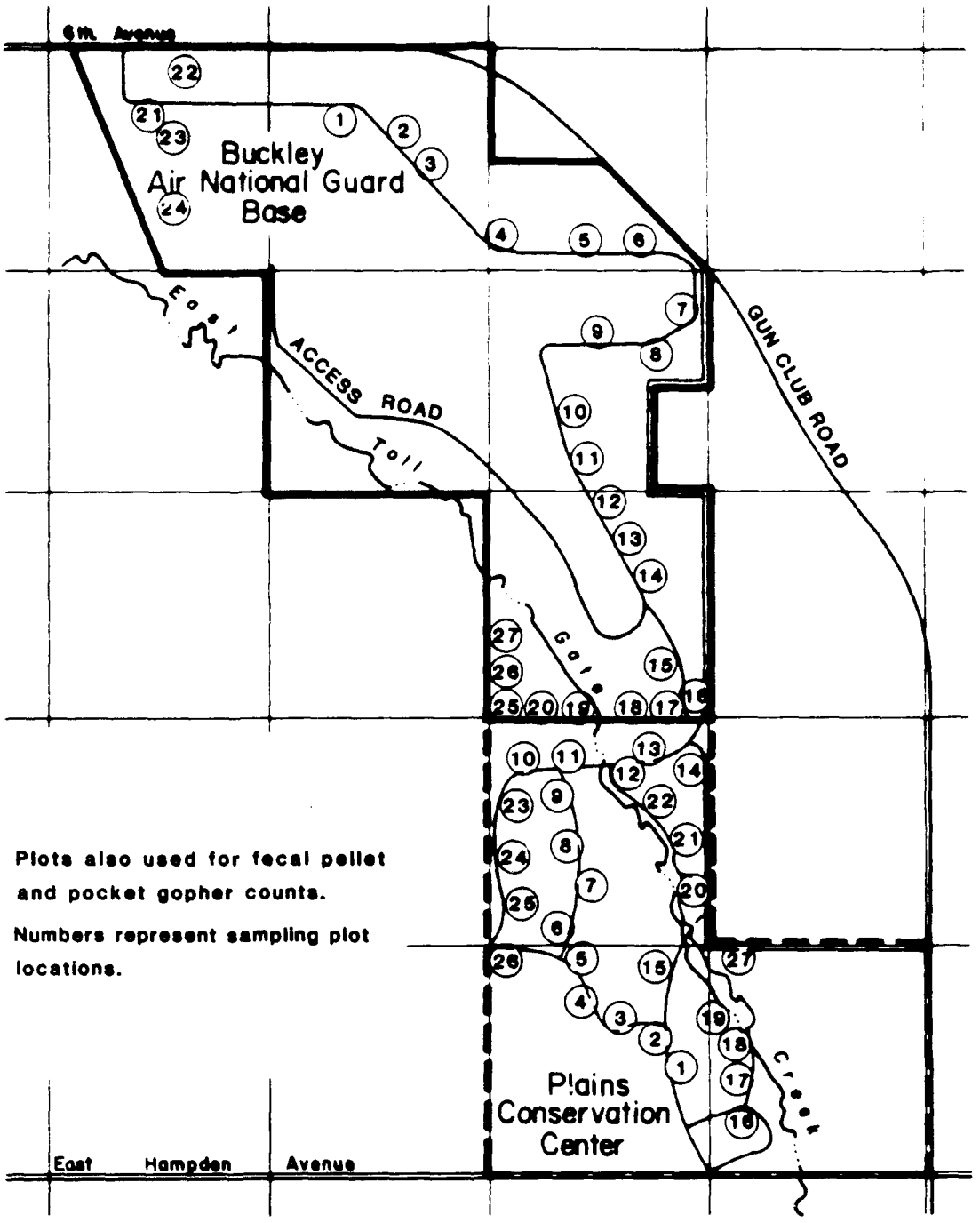
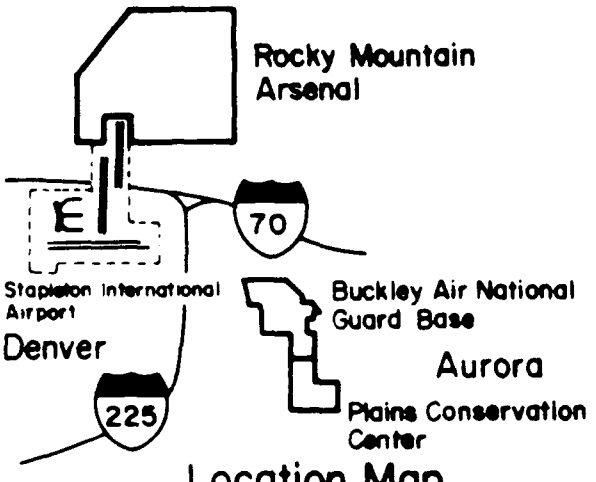


Notes: 1 Plots also used for fecal pellet and pocket gopher counts.

2 Numbers represent sampling plot locations.



Location Map

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Figure 3-11.

Breeding Songbird Plot Locations

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species per plot, was estimated at 100 points (1-m apart) along two 50-m line transects. Height of vegetation (ten observations) and number of vegetation lifeforms were estimated along these same transects. Interspersion of major vegetation types (number of types 1 ha or more in size within 100 m of the plot) was ranked from 0 to 3, low to high. Prairie dog abundance within a bird plot was also ranked 0 to 3, low to high. In all, sixteen habitat variables were used as predictor variables (independent variables) in the analyses of breeding bird habitat affinities.

The sixteen habitat variables along with their measurement units are as follows:

1	Cool season native grass	(percent coverage)
2	Warm season native grass	(percent coverage)
3	Cheatgrass	(percent coverage)
4	Crested wheatgrass	(percent coverage)
5	Perennial forbs	(percent coverage)
6	Annual forbs	(percent coverage)
7	Total vegetation	(percent coverage)
8	Bare soil	(percent coverage)
9	No. of species	(enumeration)
10	No. of lifeforms	(enumeration)
11	Height of vegetation	(centimeters)
12	Sand sagebrush	(density, ranked)
13	Rabbitbrush	(density, ranked)
14	Cactus	(density, ranked)
15	Interspersion	(ranked)
16	Prairie dog abundance	(ranked)

3.8 WATER BIRDS

Investigations of water birds focused primarily upon identifying fall and spring migrants on RMA and determining which species nested onsite. The number of water birds sighted during each observation period was also recorded as an index to relative use of the different lakes and ponds.

Water birds (waterfowl, shorebirds, wading birds, and other large aquatic birds) were counted primarily in the morning during the spring and fall migrations of 1986 (from late March

to late June, and from late October to early December). Some additional observations were made within suitable habitats during spring 1987 in an attempt to identify species that nested onsite.

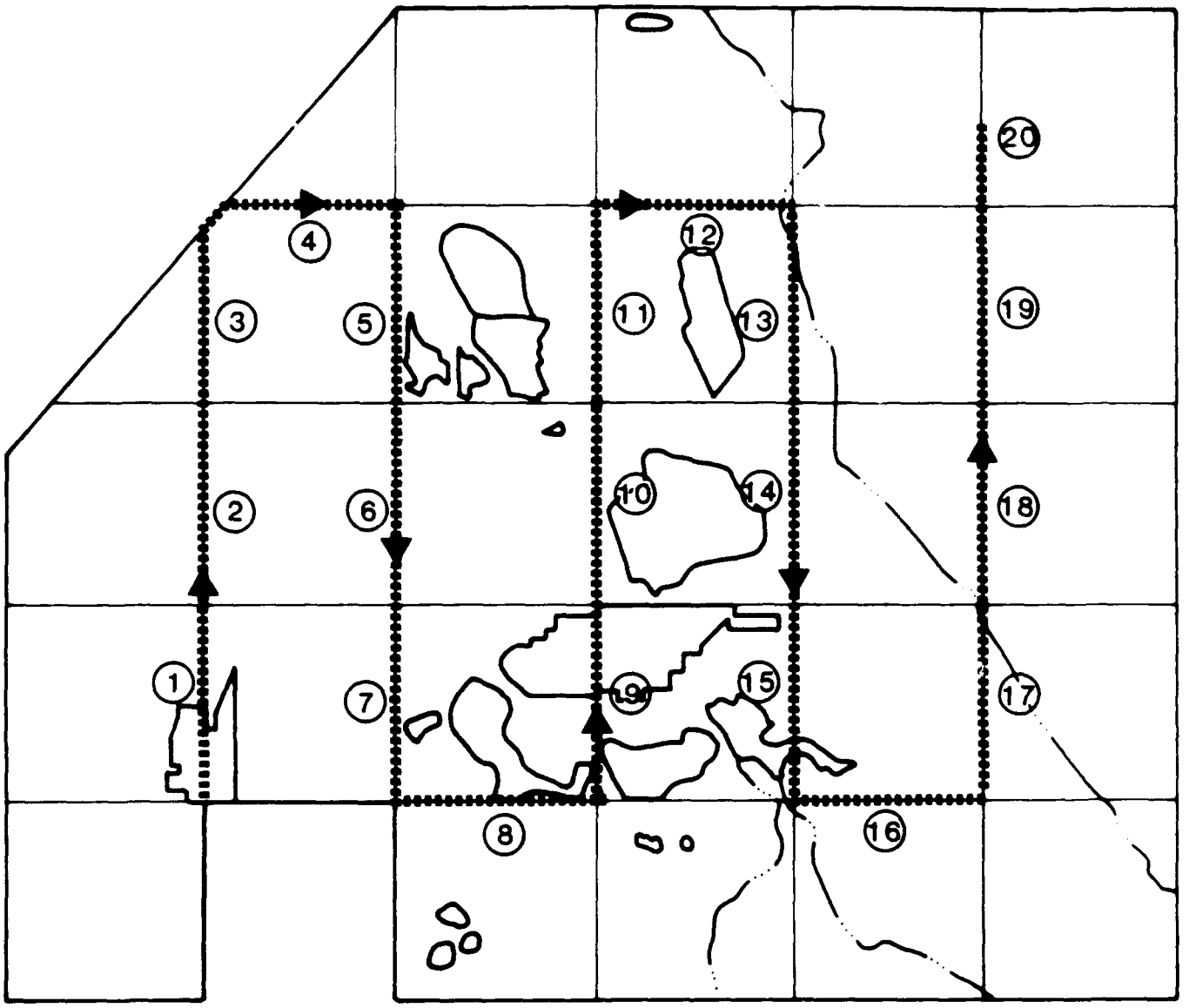
3.9 PHEASANTS AND DOVES

3.9.1 Ring-necked Pheasants

Pheasant studies consisted primarily of male vocalization ("crowing") counts in the spring and fecal pellet counts as described above for deer and rabbits. In addition, the ratio of males to females was estimated during the winter. Data were used to evaluate distribution and abundance at RMA and to compare the Arsenal with an offsite location.

Vocalizing male pheasants were counted during seventeen surveys onsite from late March to early June 1986 (Figure 3-12), and during four surveys offsite from late May to mid-June 1986 (Figure 3-13). The offsite area, in Weld County, was chosen after consulation with the CDOW. Each survey consisted of twenty listening stations spaced 1 mi apart. Surveys were conducted from approximately 45 minutes before sunrise to 75 minutes after sunrise; each listening station was visited for 2 minutes. The twenty onsite locations were visited twice weekly beginning in late March as a "check route" to estimate the period of maximum vocalization, as recommended by Kimball (1949). Additional discussions of the vocalization count method can be found in Carney and Petrides (1957), Gates (1966), and Davis and Winstead (1980).

Male-female ratios were estimated at two onsite locations in February 1986, following light snow and cool temperatures which appeared to concentrate the pheasants. Male-female ratios were obtained by driving to areas on the RMA where pheasants had often been seen. The pheasants located were flushed, and



Note: Circled numbers represent listening stations.

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Figure 3-12.

Pheasant and Dove Survey Route

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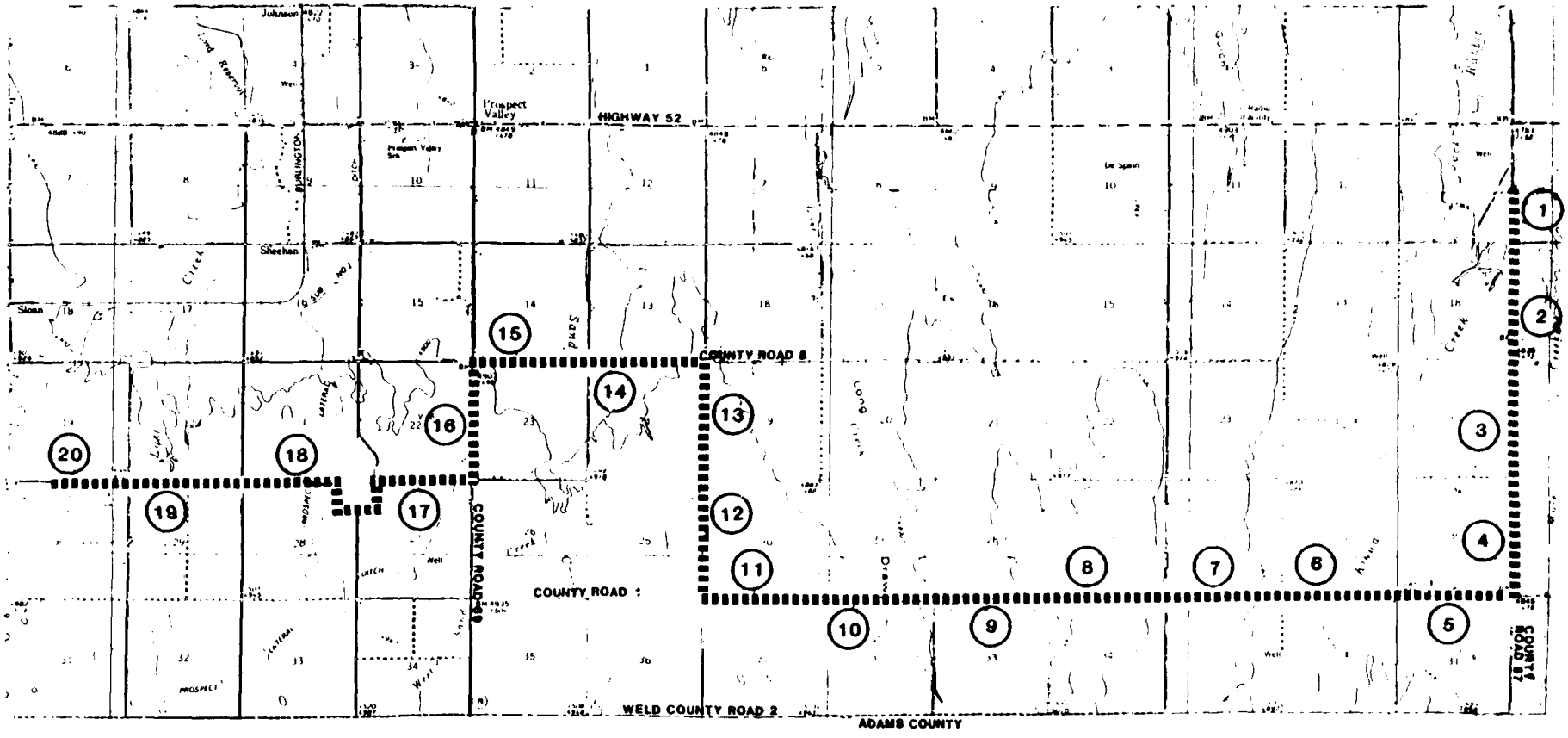

Note: Circled numbers represent listening stations.

Figure 3-13.

Pheasant Survey Route, Offsite (Weld Co.)

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enumerated by sex. The two locations were north of Basin F in Section 23, and near First Creek in the northeastern quarter of Section 6.

3.9.2 Mourning Doves

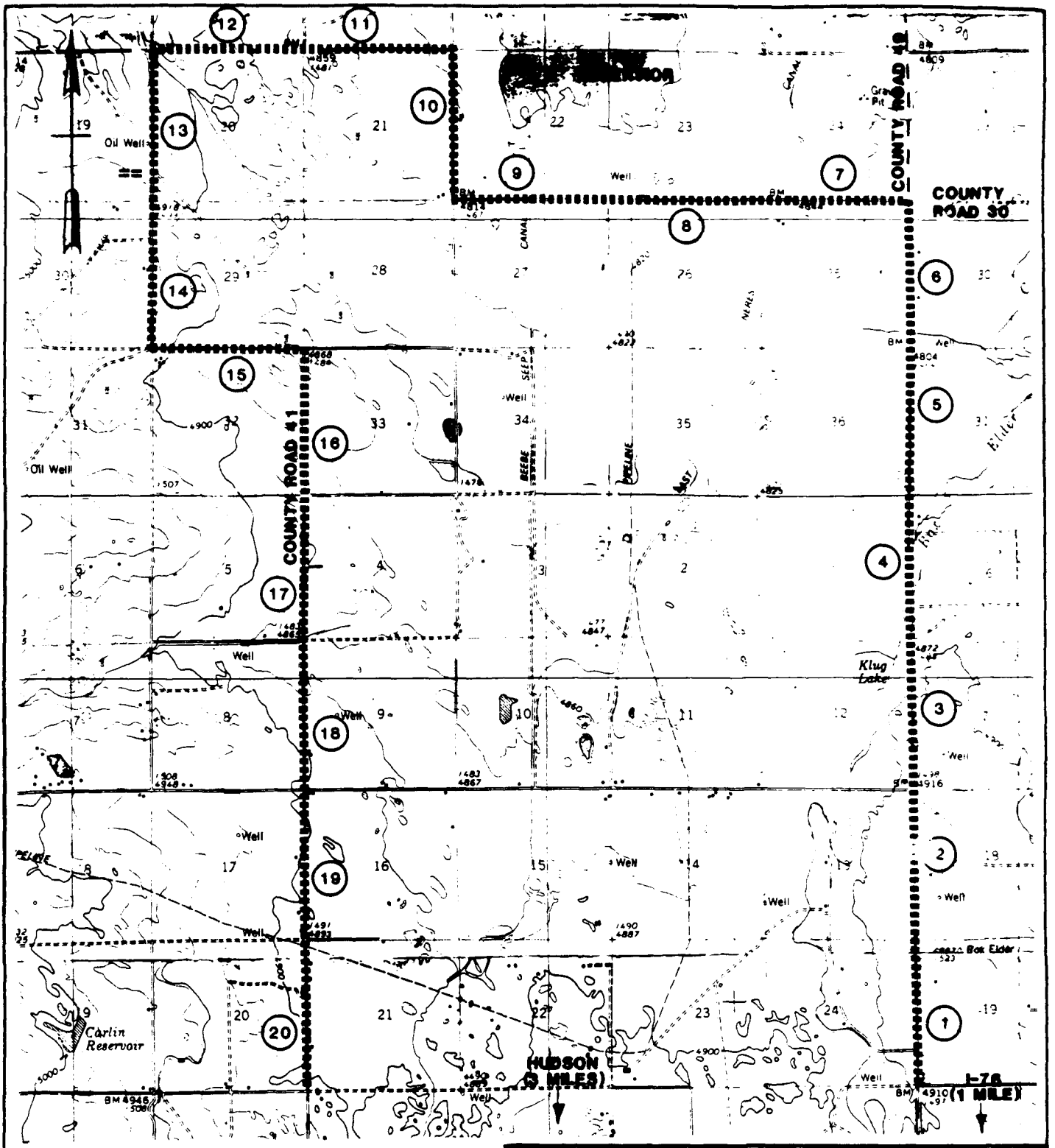
Mourning dove vocalization counts were similar to those described above for pheasants. Early morning vocalizations were counted along 20-mi routes onsite (Figure 3-12) and offsite (Figure 3-14), with listening stations at 1-mi intervals. Three counts each were conducted onsite and offsite in late June 1986, within the peak vocalization period (Stone 1963). All counts were conducted for 3 minutes, from approximately 30 minutes before sunrise to 90 minutes after sunrise. Counts were performed only during favorable weather. Procedures closely followed those described by Stone (1963) and Morrison (1969). As with pheasants, the offsite area for dove surveys was located in Weld County and chosen after consultation with the CDOW.

3.10 RAPTORS

The term "raptor" refers to eagles, hawks, falcons, and owls. Objectives of raptor investigations were to identify migrants and residents, to compare populations onsite with nearby offsite areas reported to have large raptor populations, and to evaluate use of the RMA during the breeding season. Methods used included roadside counts and nest and roost searches (Craighead and Craighead 1956, Call 1978).

3.10.1 Road Surveys

Road surveys were made from a vehicle traveling slowly (10-15 mph) along 20-mi routes both onsite and offsite (Figures 3-15 through 3-17). The first offsite route, in Arapahoe County (Figure 3-16), was discontinued after three counts because very



Note: Circled numbers represent listening stations.

Figure 3-14.

Dove Survey Route, Offsite (Weld Co.)

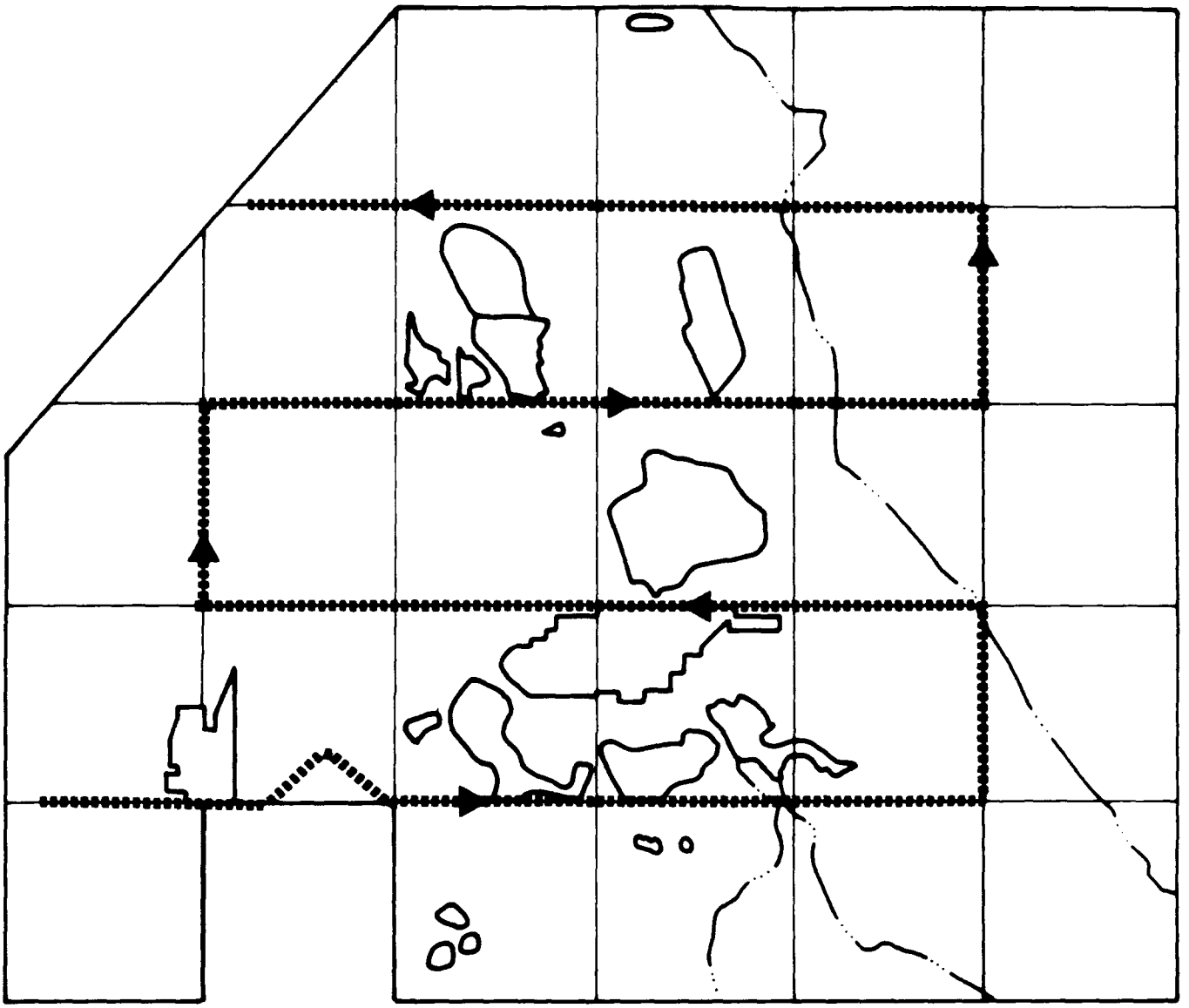


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Figure 3-15.

Raptor Survey Route

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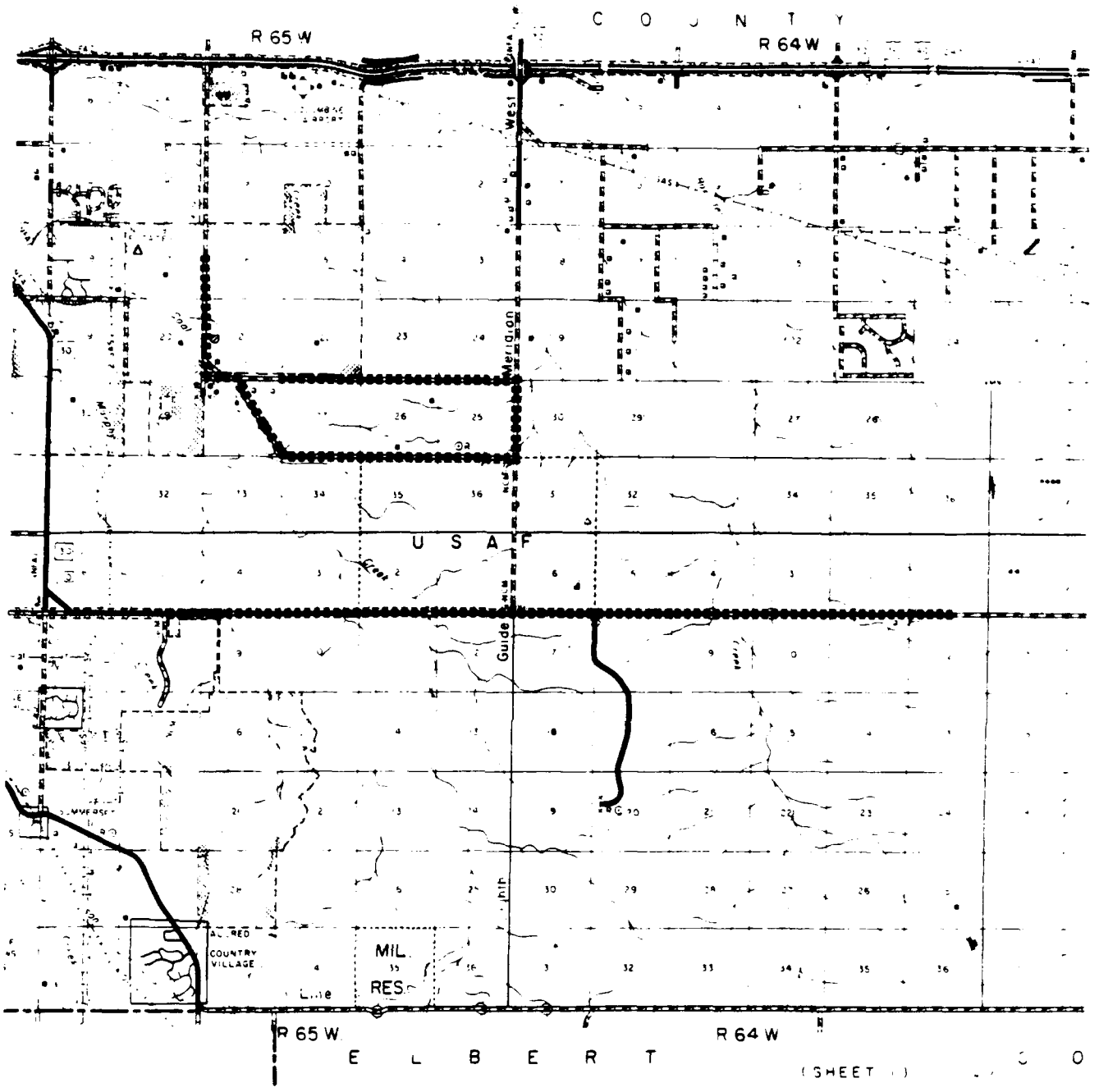

Figure 3-16.

Raptor Survey Route, Offsite (Arapahoe Co.)

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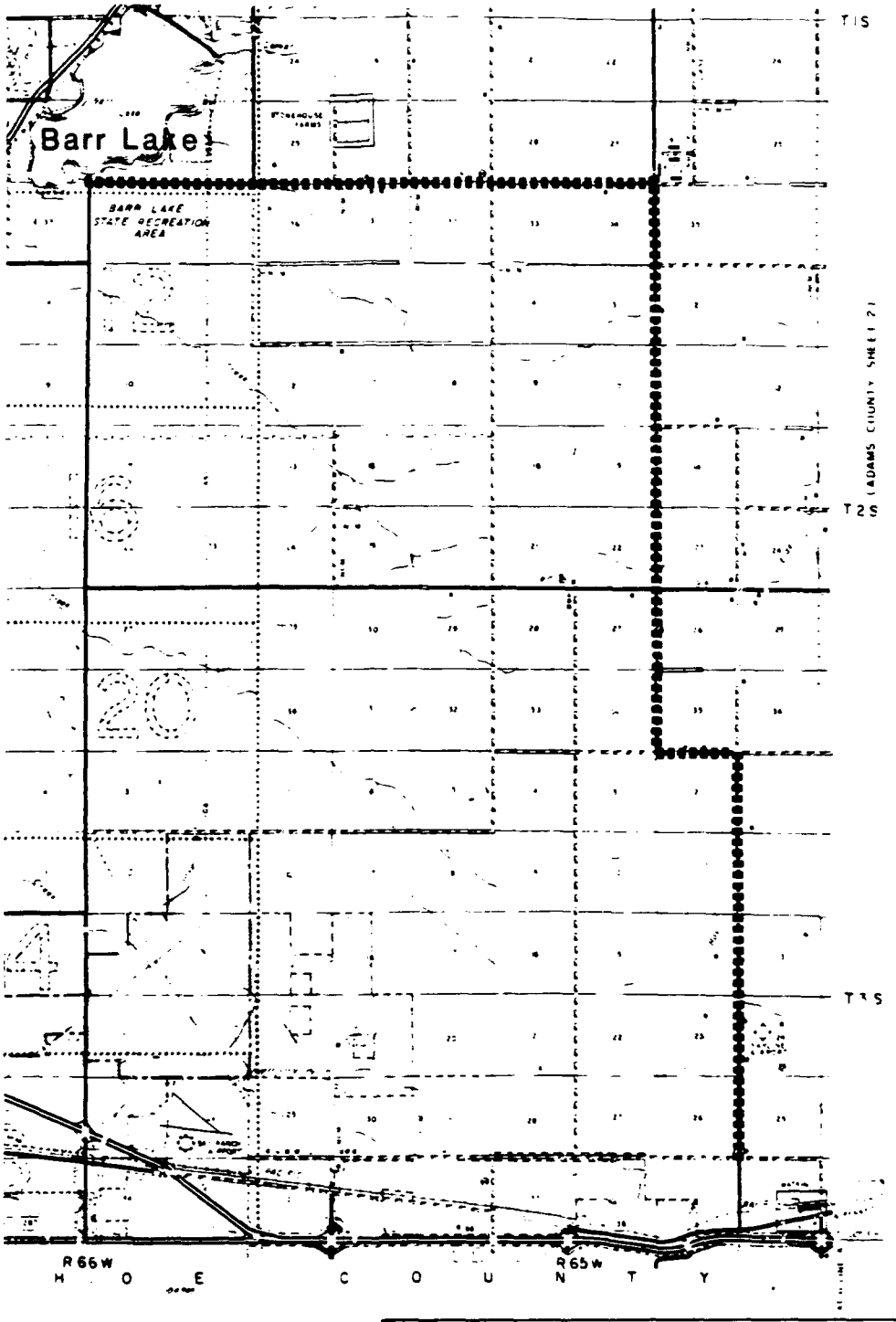

Figure 3-17.

Raptor Survey Route, Offsite (Adams Co.)

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few raptors were seen. A second route was then established in Adams county (Figure 3-17). Both offsite routes were recommended by CDOW.

A total of thirteen counts were performed onsite and offsite in winter 1986 (January 27 - March 3) followed by twelve counts in spring 1986 (April 30 - June 20). Three additional onsite counts were performed in winter 1987 (January 22 - February 11). Two observers, including the driver, conducted all counts.

All raptors sighted were recorded on maps carried in the vehicle. Additional data recorded included unusual plumage, color phase, flight direction, sex (harriers and kestrels only), and meteorological conditions.

3.10.2 Nest and Roost Searches

Searches for owl nests were conducted during winter and early spring (January to March) in 1986 and 1987. All nests and potential roost sites were examined for regurgitated food castings.

Searches for nests of raptors other than owls were conducted between June and August 1986, and between April and August 1987. All stands of medium and large trees on the RMA were examined for nests. Areas where raptors had been observed were searched more intensively.

3.11 REPTILES AND AMPHIBIANS

Most of the observations of reptiles and amphibians ("herptiles") occurred opportunistically during the various field programs described above. However, springtime surveys of permanent and ephemeral bodies of water were conducted in an effort to document breeding by anurans (frogs and toads). These surveys consisted of driving within earshot of wet areas after

dusk and identifying the species heard. Choruses of breeding anurans are readily identifiable to species, and individuals are easily heard over distances of 100 m or more.

3.12 THREATENED AND ENDANGERED SPECIES

Surveys for threatened or endangered species were not specifically included in the wildlife program conducted by MKE. Observations of such species made during the overall study (i.e., sightings of bald eagles) were reported to the Army, which cooperated with FWS in studies of bald eagles at the site.

The Army also conducted an intensive black-footed ferret survey at RMA because of the presence of extensive prairie dog colonies. We did not observe ferrets or their sign, nor did we see other federally listed threatened or endangered species (e.g., peregrine falcons, whooping cranes). Had we done so, the sightings would have been recorded and reported. A state-listed species, the white pelican, was observed on the South Lakes at RMA (especially Lower Derby Lake) on several occasions.

3.13 ANIMAL TISSUE COLLECTION

Wildlife investigations at RMA included the collection of tissue samples from selected species (mule deer, prairie dogs, cottontails, pheasants, mallards, and coots) for chemical analysis. Some tissue collection was conducted jointly by MKE and Hunter/ESE; other sampling efforts were conducted separately. Results of the tissue analyses are provided and discussed in considerable detail in the Biota RI (ESE 1989).

4.0 RESULTS AND ONSITE-OFFSITE COMPARISONS

This section presents the results of the quantitative and qualitative wildlife investigations conducted by MKE. Discussions focus on the distribution and abundance of terrestrial vertebrates across the Arsenal and on comparisons of RMA with offsite locations.

4.1 COYOTES, FOXES, AND OTHER CARNIVORES

4.1.1 Coyotes

Coyotes were found to be common on the RMA, as indicated both by general observations and results of the scent-station survey. A comparison of coyote abundance indices on the RMA with the most recent FWS data for three areas in eastern Colorado is provided in the table below. The indices reflect relative numbers only; they are not population estimates.

Location	Coyote Abundance Index	Year
RMA	325	1986 (Oct)
RMA	300	1986 (Nov)
Eastern Colorado		
Transect No. 1	195	1981
No. 2	155	1981
No. 3	128	1981
No. 1	186	1980
No. 2	140	1980
No. 3	41	1980

The FWS transects used for comparison with RMA data were selected on the basis of proximity to the RMA and similarity of habitat. The FWS coyote scent-station surveys were terminated in 1981, thus precluding comparison of results from RMA with contemporaneous data.

Coyote abundance indices reported by FWS over the 10-year period 1972-1981 ranged from 15 to 304 for eastern Colorado, from 31 to 383 for western Kansas, and from 35 to 405 for western Nebraska

(USDI 1972-81). These data indicate that the coyote population at RMA was near the upper end of the range for nearby prairie areas.

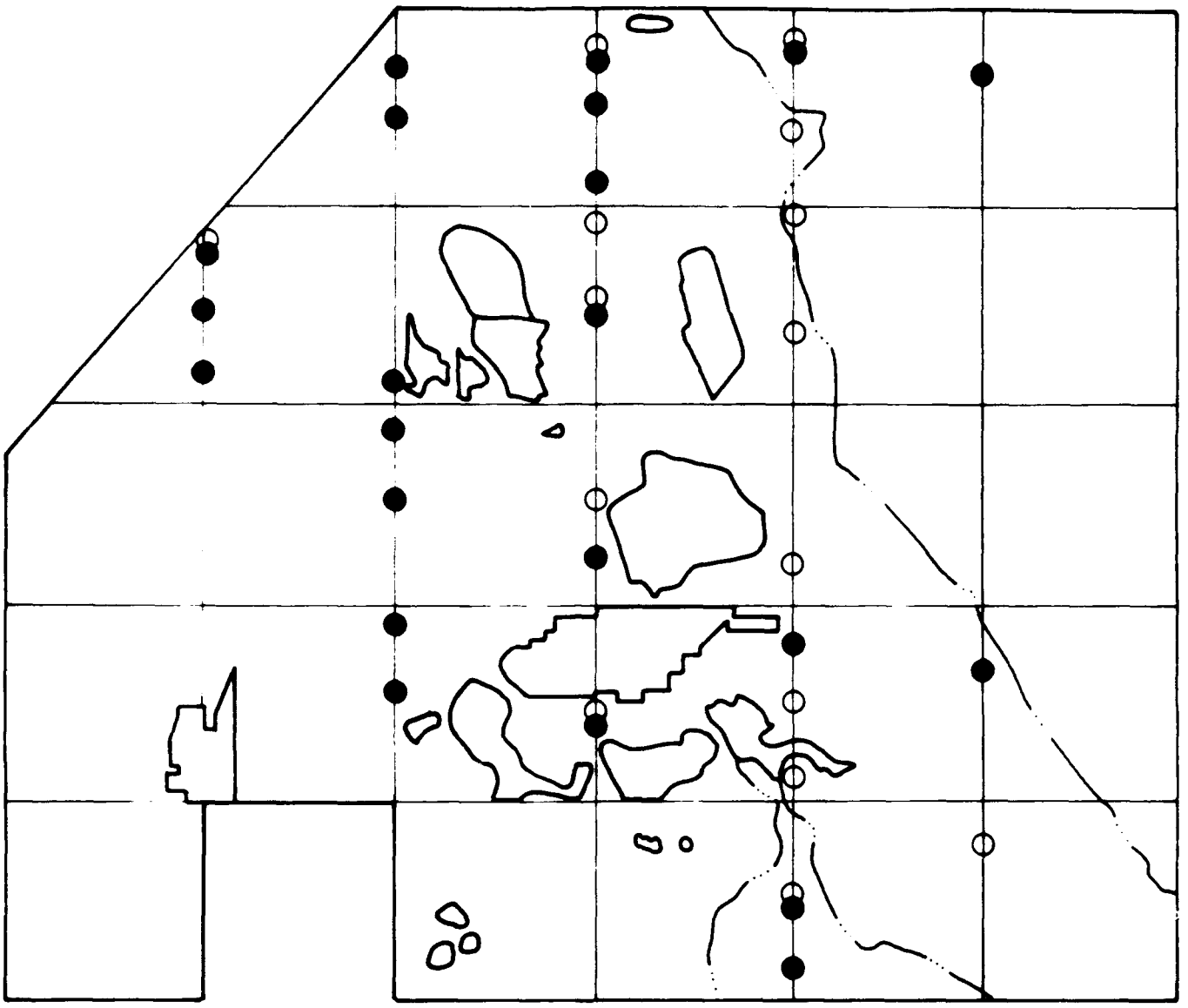
Results of scent-station surveys (Figure 4-1) indicated that most of the RMA was used by coyotes. This includes areas close to contamination sources (such as Basins A and F and the North and South Plants). It appears that coyote distribution was more strongly influenced by habitat or the availability of prey (e.g., rabbits and prairie dogs) than by contamination per se.

4.1.2 Foxes

Red foxes were occasionally observed on the RMA, and gray foxes were believed to be present based on tracks. Other field biologists working on the RMA reported sightings of both gray foxes and swift foxes (ESE 1989). Scent-station surveys produced red fox abundance indices of 150 for October 1986 and 50 for November 1986. These indices can be compared with coyote abundance indices (i.e., 300 and 325) to estimate the relative size of the two populations. The scent-station surveys suggest widespread use of RMA by red foxes (Figure 4-2).

4.1.3 Other Carnivores

Relatively little evidence of other carnivores was obtained either from tracks or casual observations. Badger tracks were recorded at only one scent station (Figure 4-2), although badgers were observed at many locations, including sites near Basins A and F. Raccoons and striped skunks were apparently uncommon on the RMA. Neither of these species was sighted, and only a few tracks were observed during searches along the muddy shores of lakes and drainages. No other carnivores were seen. Additional species potentially present include the mink, long-tailed weasel, and short-tailed weasel (Armstrong 1972).



Note: Symbols represent locations where tracks were encountered.

LEGEND

● Oct 1986

○ Nov 1986

Rocky Mountain Arsenal

Figure 4-1.

Coyote Scent Station Results

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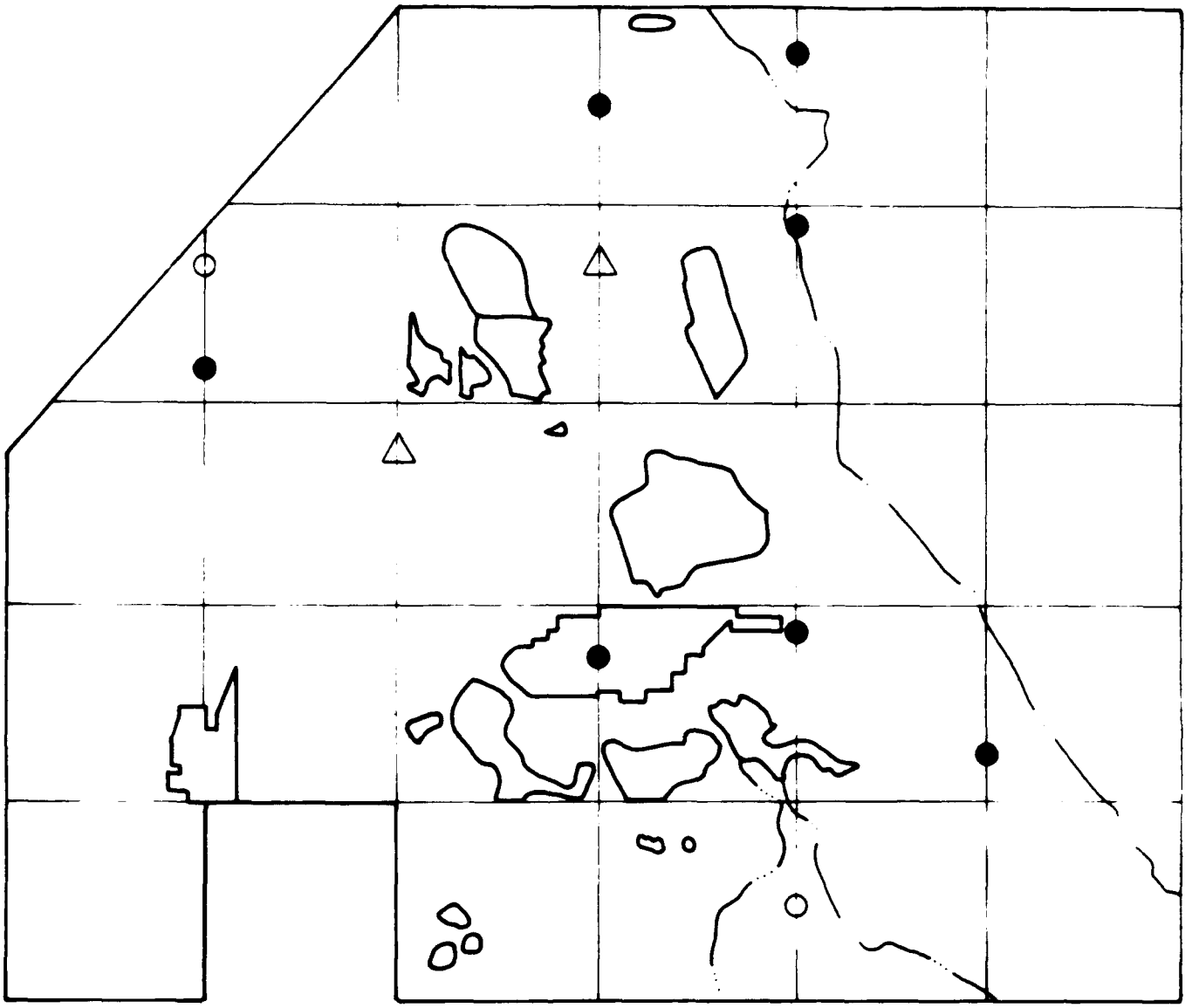


Note: Symbols represent locations where tracks were encountered.

LEGEND

Fox : ● Oct 1986

○ Nov 1986

Badger : △ Nov 1986

Rocky Mountain Arsenal

Figure 4-2.

Fox and Badger Scent Station Results

MORRISON-KNUDSEN ENGINEERS, INC

4.2 DEER

Mule deer were common and conspicuous at the RMA. White-tailed deer were not as numerous or widespread, being mostly confined to wooded areas along First Creek and the South Lakes. Both herds were believed to be largely confined to the Arsenal because of generally less suitable habitat offsite. It is expected that offsite movements by deer are greatest in the riparian corridor along First Creek, or toward Second Creek to the east of RMA.

Five attempts at a total count of deer on the RMA were made during the winter of 1986-87. These counts probably resulted in a nearly complete census of mule deer, which tended to occupy relatively open habitats at RMA. Counts of white-tailed deer were probably less complete, owing to their strong preference for areas of denser cover. Even so, however, it is unlikely that substantial numbers of either were missed on days when the highest counts were obtained.

Total counts of deer on the RMA were as follows:

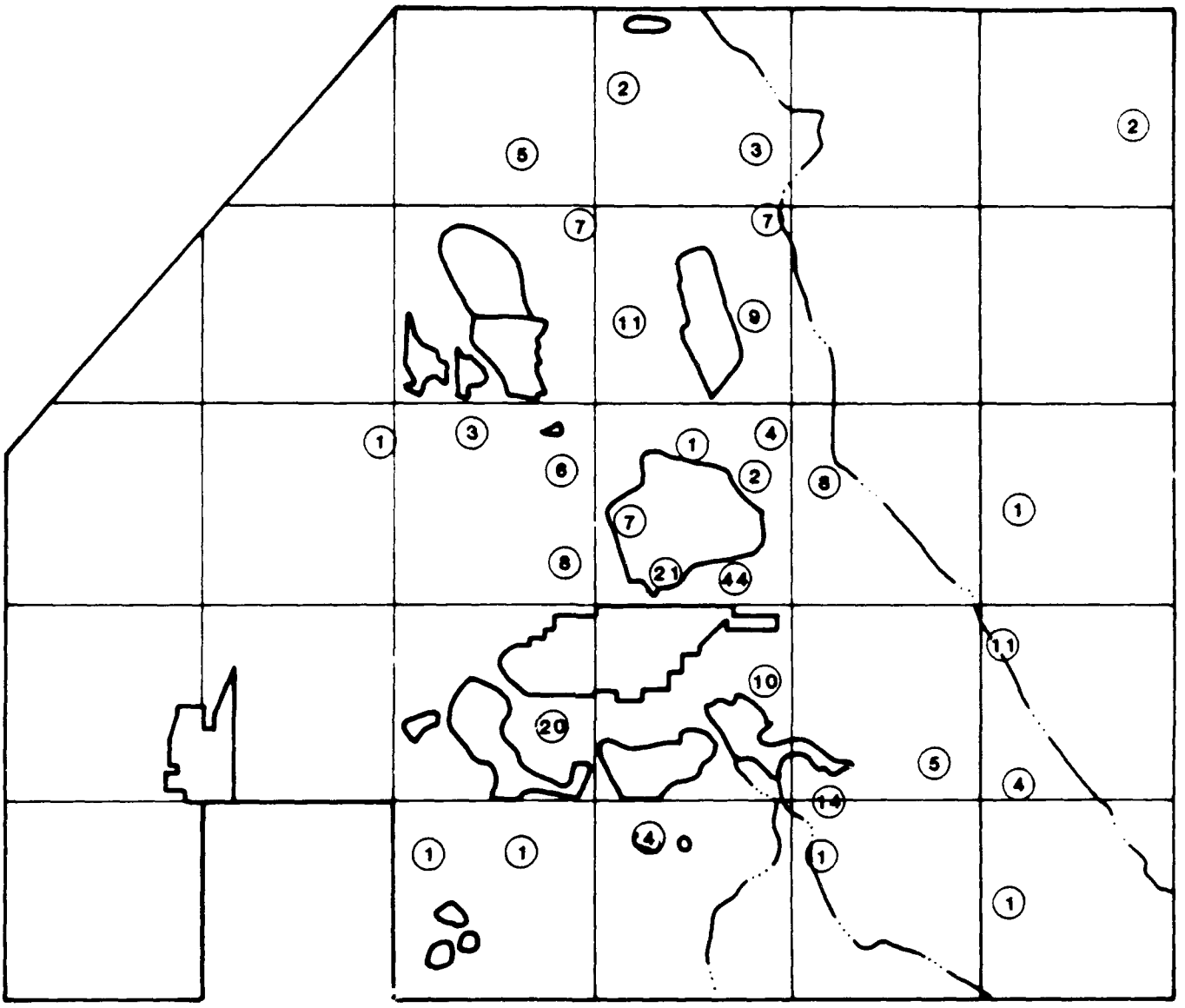
	NUMBER OF DEER OBSERVED	
Date	Mule Deer	White-tailed Deer
12 Dec 86	179	31
9 Jan 87	207	56
4 Feb 87	173	39
11 Feb 87	129	48
2 Mar 87	205	36

Based on these findings, the density of mule deer across RMA during the winter of 1986-87 was approximately 8 per square mile. In open plains habitat elsewhere in the USA, mule deer densities rarely exceed 5 deer per square mile (Mackie et al. 1982). Mule deer were observed regularly but in small numbers at Buckley and were seldom seen at PCC.

An Arsenal-wide density of white-tailed deer was not calculated because suitable habitat is restricted to riparian and wooded areas. Nonetheless, it is apparent that the white-tailed deer population at RMA is high for the vicinity. White-tailed deer were not observed at either offsite area.

These large populations of deer demonstrate that favorable habitat exists at RMA. This might seem improbable, because deer are generally reported to rely upon shrubs (which are sparse on the RMA) for food during winter. However, forbs are abundant onsite, especially weedy species. Forbs are a major component of the diet of deer and are more similar to shrubs in terms of palatability, digestability, and nutrition than are grasses. The value of forbs as a food source is enhanced by the fact that different species are green from very early spring well into autumn. The large deer populations undoubtedly also reflect a "refuge effect" because hunting is not permitted onsite and the level of human disturbance is low.

Distribution of deer on the RMA was evaluated by quantitative fecal pellet surveys and direct observation of the animals. Results of the fecal pellet surveys (Figure 4-3) agree with subjective impressions of deer distribution. During all seasons, deer were commonly observed in or near wooded areas and in areas of tall weedy vegetation. Multiple correlation analysis of fecal pellet data resulted in significant positive correlations ($P < 0.05$) with total vegetation cover and tall weedy forbs. Significant negative correlations were obtained for open habitats (e.g., prairie dog towns and areas dominated by native short-grasses) and for dense stands of cheatgrass and crested wheatgrass. This avoidance of open areas or non-native grassland probably was due to a combination of lack of cover and inadequate forage.



Note: Circled numbers represent frequency of pellets in songbird plots.

Rocky Mountain Arsenal

Figure 4-3.

Distribution of Deer Pellets

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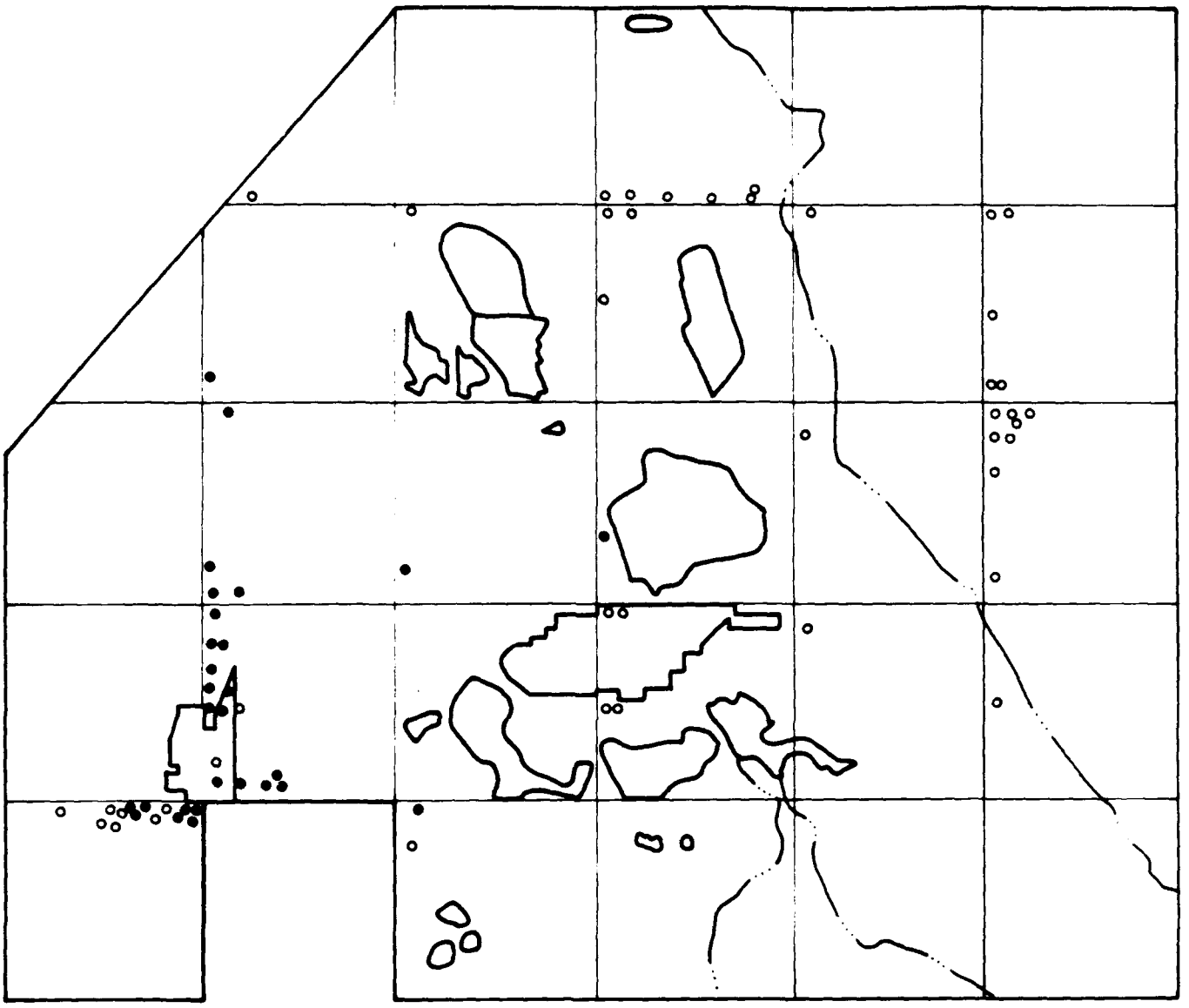
4.3 COTTONTAILS AND JACKRABBITS

Four species of rabbits were identified on the RMA: the desert cottontail, eastern cottontail, black-tailed jackrabbit, and white-tailed jackrabbit. The most abundant rabbit during field studies was the desert cottontail. This species generally prefers open habitats, such as grasslands and sparse shrublands. Desert cottontails are also commonly associated with prairie dog towns. In contrast, the eastern cottontail typically prefers areas of denser cover. At RMA, eastern cottontails were mostly limited to thickets and riparian habitats. Black-tailed jackrabbits were not as widespread as desert cottontails but were abundant in some areas, particularly the southwestern portion of the Arsenal. White-tailed jackrabbits were seldom observed at RMA.

Four nighttime roadside counts of cottontails and jackrabbits were conducted at RMA, Buckley, and PCC during the spring of 1986. Figures 4-4 and 4-5 depict the number and location of rabbit observations during the surveys. Quantitative results of the road transects were as follows:

	Number Observed (mean/mile)	
Location/Date	Cottontails	Jackrabbits
RMA:		
28 Apr 86	0.65	0.50
1 May 86	0.90	0.15
21 May 86	0.45	0.45
16 Jun 86	0.10	0.30
Buckley & PCC:		
7 May 86	0.90	1.94
12 May 86	0.56	1.18
29 May 86	0.35	0.69
18 Jun 86	0.14	1.11

The mean number of cottontails seen per mile onsite (0.52) was not significantly different from the number offsite (0.49). However, the lower number of jackrabbits observed onsite (0.35



Note: Symbols represent sightings, Spring 1986.

LEGEND

- ○ Cottontails
- • Jackrabbits

Rocky Mountain Arsenal

Figure 4-4.

Results of Rabbit Roadside Counts

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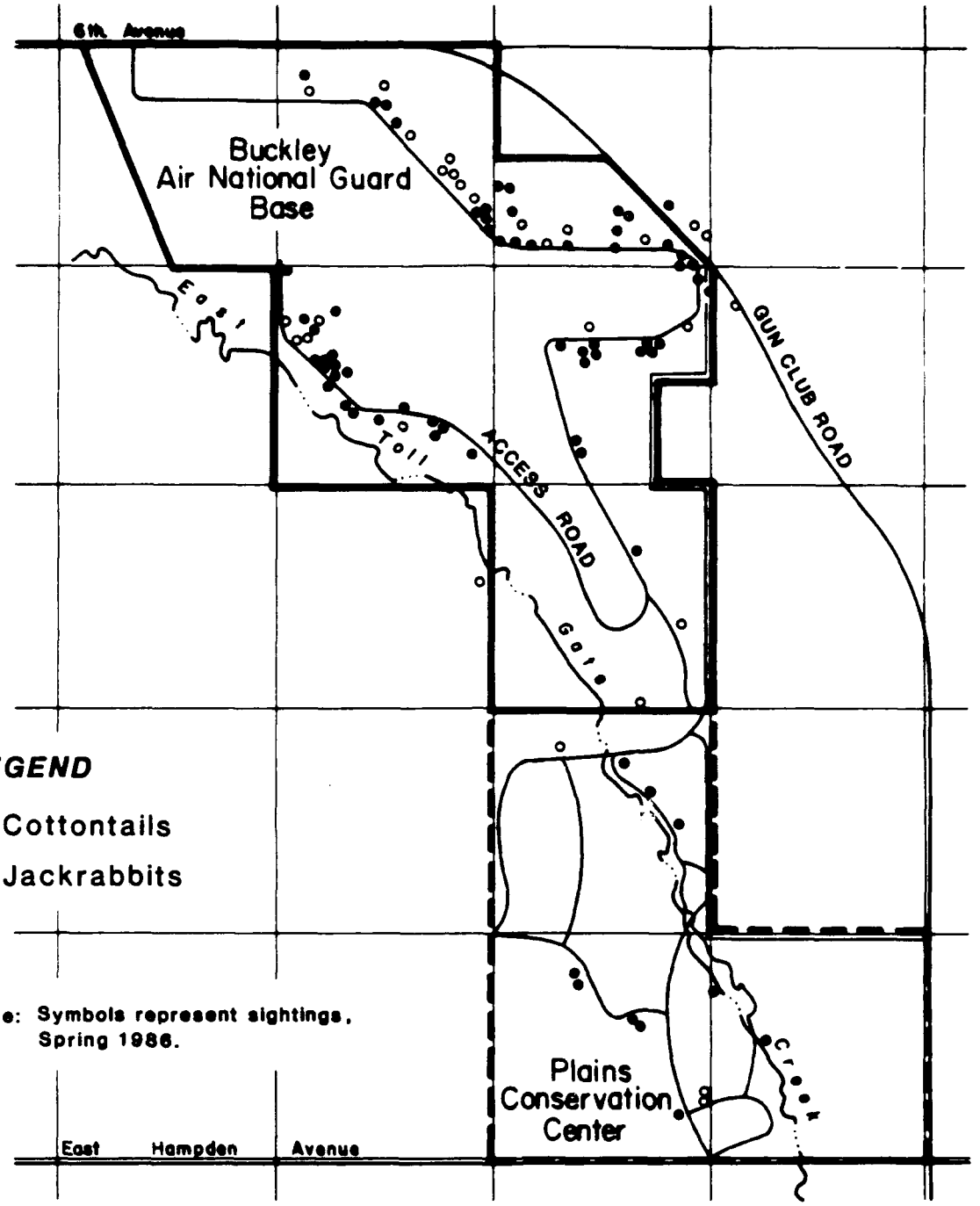

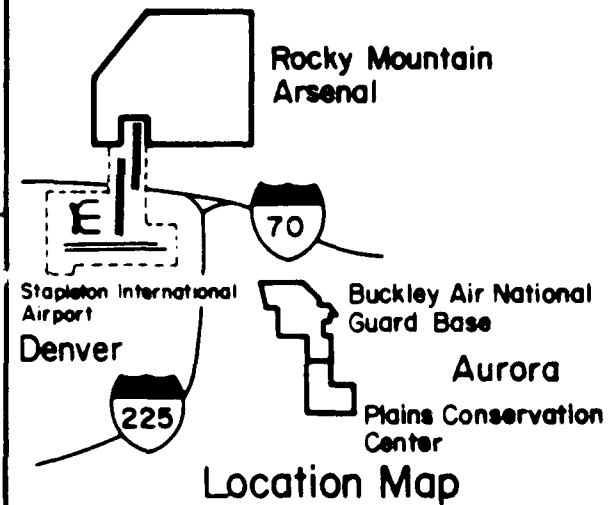

Buckley Air National Guard Base and Plains Conservation Center

Figure 4-5.

Results of Rabbit Roadside Counts

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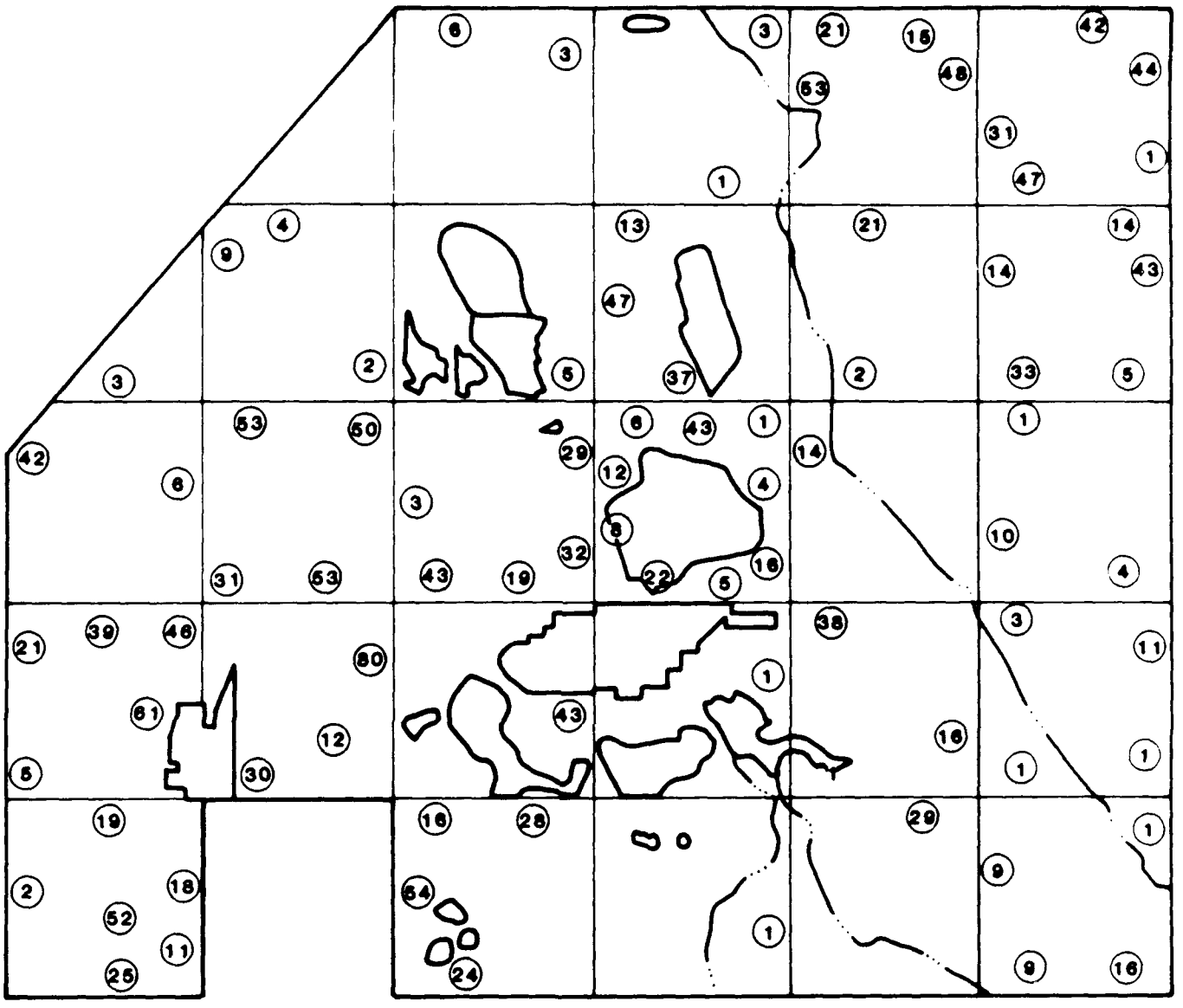
versus 1.23) was significant ($t = 3.24$, $df = 6$, $P < 0.02$). Reasons for this difference are not known. A t-test was also used to compare differences in fecal pellet densities between the RMA and offsite areas; these differences were not significant ($t = 1.23$, $df = 163$, $P > 0.20$).

Habitat affinities of cottontails and jackrabbits combined, based on fecal pellet data (Figure 4-6) and vegetation data, were evaluated using multiple correlation analysis. Significant positive correlations were obtained for the amount of crested wheatgrass, diversity of plant species, and presence of prairie dogs. A negative correlation was obtained for total vegetation cover. These correlations describe a general affinity for open habitats, which conforms with the reported habitat preferences of the two most common species, the desert cottontail and the black-tailed jackrabbit.

4.4 PRAIRIE DOGS

Black-tailed prairie dogs were the most conspicuous mammal on the RMA. During field studies in 1986 and 1987, they formed extensive colonies especially in the northern half of the site (Figure 4-7). Past aerial photographs indicate that prairie dogs have been a major component of the mammalian fauna for much of the RMA's history, and that the towns were in a phase of expansion at the time of the MKE investigations.

Estimates of adult-young ratios (Table 4-1) suggest that prairie dog productivity was lower at the RMA than at the two offsite locations. In 1986, young comprised 47 percent of the prairie dog population at twenty onsite locations (range = 29-69 percent), compared to a mean of 61 percent (range = 38-77 percent) at the twenty offsite locations. In 1987, the mean onsite was 62 percent (range = 41-81 percent), compared to 77 percent offsite (range = 66-87 percent). The proportion of



Note: Circled numbers represent frequency of pellets in songbird plots.

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Figure 4-6.

Distribution of Rabbit Pellets

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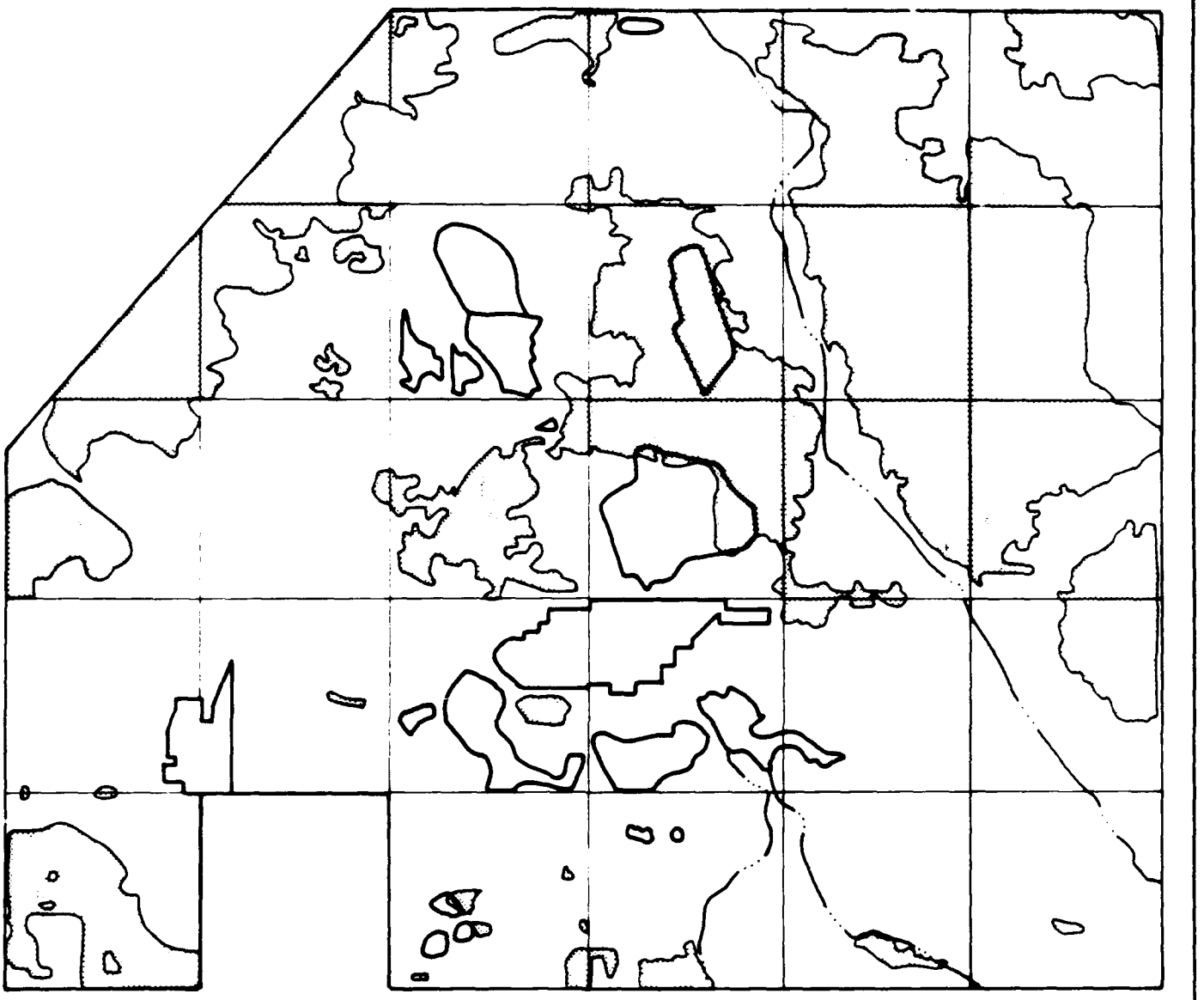
TABLE 4-1

PERCENT OF YOUNG PRAIRIE DOGS AT EACH SAMPLING LOCATION

RMA			OFFSITE			
Location No.		Percent	Location No.		Percent	
		1986	1987		1986	1987
	1	43	60	Buckley 1	62	83
	2	30	67	2	63	70
	3	47	47	3	63	81
	4	49	59	4	77	81
	5	61	70	5		75
	6	44	61	6		73
	7	34	58	7		84
	8	49	47	8		81
	9	29	55	9		72
	10	61	63	10		66
	11	57	41			
	12	50	78	PCC 1		67
	13	41	76	2		70
	14	56	63	3		87
	15	40	53	4		83
	16	16	77	5	61	81
	17	65	62	6	38	74
	18	69	63	7		87
	19	41	66	8		76
	20	48	81	9		73
				10		82
Mean		47	62	Mean	61	77



Note: Map prepared by ESE (1987).

LEGEND

☐ Prairie dog colonies

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Figure 4-7.

Location of Prairie Dog Colonies

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young animals onsite was 23 percent lower than offsite in 1986, and 20 percent lower than offsite in 1987. These differences were statistically significant (for 1986: $t = 2.31$, $df = 24$, $P < 0.05$; for 1987: $t = 5.3$, $df = 38$, $P < 0.001$).

Lower prairie dog productivity on the RMA might have resulted from natural variations, size and age of the colonies, habitat suitability, predation, or contamination effects. If contamination were causally involved, one would expect the lowest productivity near areas of known contamination. This was not the case. The proportion of young animals closest to contamination areas (Locations 5, 13, 17, and 18) was higher both years than at more distant locations (59 percent vs. 43 percent in 1986; 68 percent vs. 61 percent in 1987). It therefore appears that normal ecological factors accounted for the different adult-young ratios.

Vegetation studies conducted on the RMA and at Buckley and PCC (Keammerer 1987) indicated that plant communities at the offsite locations contained a higher proportion of the foods preferred by black-tailed prairie dogs (Summers and Linder 1978). Studies of black-tailed prairie dogs elsewhere have shown that colonies occupying superior habitat have larger litters, a greater proportion of successful pregnancies, and higher survival rates (Garrett et al. 1982). In addition, increased predation by raptors and coyotes at RMA could be expected to depress the number of young disproportionately, since they are less experienced and thus more vulnerable.

A detailed discussion of prairie dog density and distribution is provided in the Biota RI (ESE 1989). It should be noted that an outbreak of sylvatic plague in late 1988 and 1989 deciminated the prairie dog population at RMA (Ebasco 1989).

4.5 SMALL MAMMALS

Seven species of small mammals were captured during both November 1986 (Table 4-2) and June 1987 (Table 4-3), although species composition differed slightly. In 1986, only five of the sixteen sampling locations at RMA had moderate to high populations, as indicated by capture frequencies (number of captures/number of trap-nights) greater than 10 percent. The remaining eleven locations all had low populations of small mammals. In 1987, the ten locations at RMA were evenly split between low and moderate-to-high populations. Statistical tests of differences in abundance among locations were not practicable because of the low capture frequencies.

In 1986, live-trapping was also conducted at Buckley Air National Guard Base (see Figure 3-7). A comparison of results between the offsite area and analogous onsite habitats showed that native grasslands had a higher mean abundance (number per 100 trap-nights) at Buckley than at RMA (9.4 versus 1.2). The same pattern was true for crested wheatgrass (5.6 versus 2.8), but not for cheatgrass (3.3 versus 8.6). These differences were apparently related to differences in habitat, rather than to contamination per se, because the highest abundances at RMA were in weedy areas near the disposal basins and manufacturing areas.

Deer mice were the most abundant and widespread small rodent at RMA during both years, and at Buckley in 1986. Offsite trapping was not conducted in 1987. This species was especially common in an area of tall weedy forbs north of Basin F, probably because of the abundant seeds provided by the weeds (deer mice are primarily granivorous). Capture frequencies were also high in short weedy forbs, cheatgrass, and stands of yucca. The deer mouse is very common throughout Colorado and is one of the most

TABLE 4-2

RELATIVE ABUNDANCE OF SMALL MAMMALS AT RMA, FALL 1986[1]

Species	Tall Weedy Forbs	Short Weedy Forbs	Cheatgrass	Crested Wheatgrass	Native Grass	[2]Shrubs/ Yucca	Cottonwoods
Deer Mouse	31.9	15.6	8.3	2.5	0.3	13.9	1.1
Plains Harvest Mouse	2.2	--	--	--	--	--	1.1
Western Harvest Mouse	--	--	--	--	--	2.2	--
Northern Grasshopper Mouse	--	--	--	--	0.6	3.3	--
Meadow Vole	--	--	--	--	--	--	7.8
Prairie Vole	0.3	--	0.3	0.3	0.3	--	--
Ord's Kangaroo Rat	--	--	--	--	--	1.1	--
Total	34.4	15.6	8.6	2.8	1.2	20.5	10.0
Locations[3]	2,12	17	1,6,13,15	3,5,11,14	4,10	18,19	16

[1] Relative abundance = number caught per 100 trap-nights.
[2] Shrubs include sand sagebrush and rubber rabbitbrush.
[3] Locations shown on Figure 3-8.

TABLE 4-3

RELATIVE ABUNDANCE OF SMALL MAMMALS AT RMA, SPRING 1987[1]

Species	Weedy Forbs	[2]Shrubs/ Yucca	[3]Thickets	Cattails/ Rushes	Streamside Meadows	Cottonwoods
Deer Mouse	30.0	9.8	2.7	2.6	1.0	1.0
Western Harvest Mouse	--	2.2	2.2	3.1	1.5	--
Meadow Vole	--	0.4	--	11.7	1.0	--
Prairie Vole	--	1.6	2.2	5.7	--	--
Silky Pocket Mouse	--	0.2	--	--	--	--
Hispid Pocket Mouse	--	0.8	--	--	--	--
Ord's Kangaroo Rat	--	2.5	--	--	--	--
Total	30.0	17.5	7.1	23.1	3.5	1.0
Locations[4]	27	23,24,28	22,25	20,21	26	29

1 Relative abundance = number caught per 100 trap-nights.
2 Shrubs include sand sagebrush and rubber rabbitbrush.
3 Thickets include New Mexico locust and American plum.
4 Locations shown on Figure 3-8.

widely distributed mammals in North America (Hall and Kelson 1959). It probably occurred in most of the habitat types on the RMA.

Two species of voles were identified: the prairie vole and the meadow vole. These two species, along with the deer mouse, probably comprised a substantial proportion of the total prey base on the RMA. Despite low capture rates in 1986 (Table 4-2), different habitat affinities between prairie and meadow voles were apparent. Specifically, the prairie vole was caught in upland grasslands, while the meadow vole was caught only in a riparian area. In 1987 (Table 4-3), both species showed a strong affinity for cattails, although the prairie vole was also fairly common in sand sagebrush and locust thickets. Both species generally favor habitats having a well developed grass-forb ground cover, with the meadow vole showing a stronger affinity for moist areas (Findley 1954, Stoecker 1972). Voles feed primarily on green plant tissue.

Two species of harvest mice--the plains harvest mouse and the western harvest mouse--were captured at RMA. In 1986, the plains harvest mouse was caught in weedy forb and riparian habitats, while the western harvest mouse was recorded only in sand sagebrush (Table 4-2). In 1987, only the western harvest mouse was captured, but in a wide range of habitats (Table 4-3). These two harvest mice species are reported to have similar habitat affinities, with the western harvest mouse tending to occur in denser stands of grass (Hall and Kelson 1959). Like deer mice, harvest mice feed primarily on seeds.

The northern grasshopper mouse was captured only in native grassland and yucca habitats (Table 4-2). This is consistent with observations that grasshopper mice tend to prefer native vegetation and to avoid weedy areas (D. Armstrong, personal communication). The northern grasshopper mouse occurs widely throughout Colorado but is seldom common at any given site. It

is an unusual mouse species in that it is carnivorous, feeding primarily on arthropods and occasionally on other mice (Armstrong 1972).

Ord's kangaroo rats were captured exclusively in yucca habitat in both 1986 and 1987 (Tables 4-2 and 4-3). Armstrong (1972) reported the species from a number of high plains locations along the Front Range of Colorado, although it is more common in the southwestern desert. The Ord's kangaroo rat tends to prefer sandy soils but is known to occupy habitats with hard soils as well (Burt and Grossenheider 1976). Kangaroo rats are able to live entirely without water, being physiologically capable of obtaining metabolic water from the digestion of seeds.

Two additional species of small mammals were captured in 1987 (Table 4-3). A single silky pocket mouse was captured in sand sagebrush near the southeastern corner of the RMA. Although widely distributed in the plains of eastern Colorado, silky pocket mice are rarely abundant (Armstrong 1972). Four hispid pocket mice were captured at this same location. The hispid pocket mouse is closely related to the silky pocket mouse but is much larger. Of the 21 species of pocket mice that occur in the U.S., the hispid pocket mouse is the largest; the silky pocket mouse is one of the smallest, hardly a third the size of a house mouse. Both species feed primarily on seeds.

Several additional small mammal species could occur at RMA, based on their reported ranges and habitat preferences (Armstrong 1972, Bissell and Dillon 1982). These include the masked shrew, least shrew, olive-backed pocket mouse, plains pocket mouse, meadow jumping mouse, house mouse, and Norway rat. The latter two species are probably present in or around abandoned buildings.

4.6 OTHER MAMMALS

4.6.1 Muskrats and Beavers

Muskrats were present on all the lakes and ponds sampled at RMA in 1986. Virtually every suitable habitat of any appreciable extent showed recent signs of muskrat activity. Muskrat houses were distributed as follows:

Water Body	No. of Houses	Approximate Length of Shoreline Sampled (m)
North Bog Pond	1	525
First Crk.(Sec. 24, 25)	2	525
First Crk. (Sec. 5, 8)	1	700
Rod and Gun Club Pond	2	200
Lower Derby Lake	1	375
Lake Ladora	7	425
Lake Mary	1	450

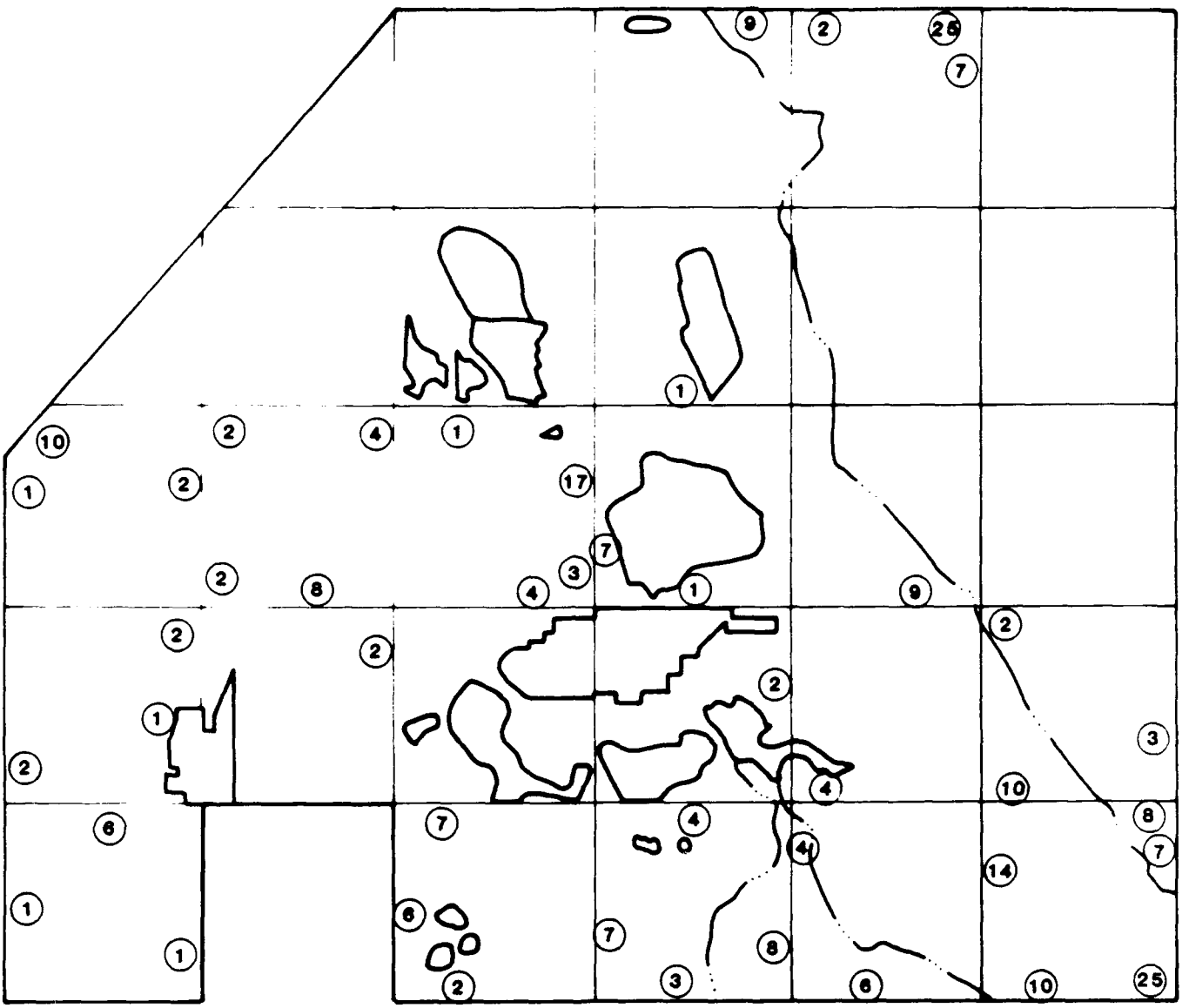
Beavers have not been observed at RMA, but they are common in the region. It is therefore possible that beavers could occur at some time in the future, especially along First Creek or the South Lakes.

4.6.2 Pocket Gophers

Pocket gopher activity was observed over much of the RMA (Figure 4-8). Only study plots in the northeastern and northwestern portions of the RMA, and Section 2 near the center, were devoid of evidence of pocket gophers. The distribution of pocket gophers at RMA appeared to bear little relationship to major contamination sources.

A multiple correlation analysis of pocket gopher habitat affinity identified two strongly negative correlations (i.e., habitat types avoided): (1) areas with dense stands of crested wheatgrass, and (2) prairie dog towns. A significant positive correlation was found for diversity of plant lifeforms.

Based on known distribution, the plains pocket gopher is the species expected to occur at RMA (Armstrong 1972, Bissell and



Note: Circled numbers represent number of mounds encountered in songbird plots.

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Figure 4-8.

Distribution of Pocket Gopher Mounds

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Dillon 1982). Miller (1964) reported that plains pocket gophers prefer sandy soils supporting abundant native forbs. This is consistent with the correlation analysis. The two habitats avoided at RMA--crested wheatgrass and prairie dog towns--typically have a low diversity and productivity of native forbs. The positive correlation with lifeform diversity probably is related to the fact that undisturbed habitats, which tended to have more abundant native forbs, were mostly confined to sandier substrates.

A second species, the northern pocket gopher, could be present onsite, but the RMA is at the extreme eastern limit of its range (Armstrong 1972).

4.6.3 Squirrels

Both the thirteen-lined ground squirrel and the spotted ground squirrel were observed at RMA. Thirteen-lined ground squirrels were seen during small mammal live-trapping in May, June, and July 1987 but were not captured. Most of the observations were along roads near open, grassy areas. Spotted ground squirrels were seen only once, in May 1987 near the center of Section 9. Spotted ground squirrels inhabit areas of sandy soil in eastern Colorado and reportedly are never abundant (Armstrong 1972). This is in marked contrast to the thirteen-lined ground squirrel, which at times reaches pest proportions in agricultural areas. Thirteen-lined ground squirrels were common in the Basin C Agricultural Test Plot, an area planted to wheat and milo by Shell/MKE in Section 26.

Fox squirrels were present in small numbers, mostly in riparian woodlands and upland groves. The fox squirrel is common in city parks and in subdivisions along the Front Range; it reportedly was introduced into the area 60 to 80 years ago (Armstrong 1972).

4.7 SMALL BIRDS

4.7.1 Winter Surveys

The most conspicuous winter songbirds at RMA were the horned lark and western meadowlark. Horned larks were the more numerous of the two during quantitative surveys (Table 4-4), with a mean of 2.7 birds/1000 m of transect length. Western meadowlarks were not as abundant, averaging only 1.2 birds/1000 m of transect length, but they were encountered in nine habitats versus seven for the horned lark.

Horned larks were generally most abundant in habitats with low, sparse vegetation, such as prairie dog towns and some native grasslands. Western meadowlarks preferred taller vegetation including crested wheatgrass, tall weedy forbs, and shrubs or yucca. The only habitat accounting for substantial numbers of both horned larks and meadowlarks was cheatgrass/perennial grass. The habitat selection exhibited at RMA by these species is typical for the region.

The only other songbirds encountered along the winter transect routes were red-winged blackbirds and song sparrows, which were essentially restricted to cattail marshes, and American tree sparrows, which were observed primarily in rubber rabbitbrush, native grassland, cattails, and tall weedy forbs. Tree sparrows were also abundant and widespread in some of the habitats where winter transect data were not collected, such as riparian woodlands, upland groves, and brushy areas along the various canals and ditches.

Dark-eyed juncos (including the slate-colored, gray-headed, and Oregon/pink-sided subspecies), white-crowned sparrows, and pine siskins were the other most common winter songbirds. All of these species were most numerous in wooded or brushy areas, and in landscaped areas near buildings.

TABLE 4-4

RELATIVE ABUNDANCE OF WINTER SONGBIRDS[1]

Habitat Type	Horned Lark	Western Meadowlark	Red-winged Blackbird	Song Sparrow	Tree Sparrow	Number of Counts	Total Transect Length (m)
RMA:							
Weedy forbs (tall)	0.3	2.3	0	0	0.7	6	3000
Weedy forbs (short)	15.0	0	0	0	0	6	3000
Cheatgrass/weedy forbs	4.0	0.7	0	0	0	3	1500
Cheatgrass/perennial grass	5.3	1.8	0	0	0	15	4500
Native perennial grass	1.6	0.7	0	0	1.7	15	7500
Crested wheatgrass	0.7	2.4	0	0	0	9	4500
Sand sagebrush	0.4	1.8	0	0	0	9	2250
Rubber rabbitbrush	0	1.3	0	0	4.0	3	750
Yucca	0	1.0	0	0	0	6	3000
Cattail marsh	0	.3	22.0	5.0	1.3	9	3000
BUCKLEY:							
Crested wheatgrass	0	4.7	0	0	0	9	3600
Cheatgrass/perennial grass	5.3	10.7	0	0	0	3	1500
Weedy forbs (short)	2.0	2.7	0	0	0	3	1500
PCC:							
Cheatgrass/perennial grass	9.5	1.0	0	0	0	3	1050
Native perennial grass	20.0	1.0	0	0	0	12	4500

[1] Data are mean number of birds per 1000 m of transect length

Less abundant winter songbirds observed at RMA included the northern shrike and American pipit in open terrain, and the Townsend's solitaire and cedar waxwing in ornamental tree plantings. Winter species that were essentially limited to stands of mature trees included the black-capped chickadee, brown creeper, white-breasted nuthatch, red-breasted nuthatch, golden-crowned kinglet, and ruby-crowned kinglet.

Some year-round residents such as black-billed magpies, European starlings, house sparrows, and house finches were prominant members of the winter avifauna in their respective habitats.

Winter songbirds at the two offsite areas were mostly limited to grassland species (horned lark, meadowlark) and species generally found near human habitations (house sparrow, house finch). An area of sparse ornamental trees and shrubs in the northwestern corner of Buckley attracted many of the species found in similar areas of RMA, such as black-billed magpies, black-capped chickadees, Townsend's solitaires, cedar waxwings, pine siskins, dark-eyed juncos, and American tree sparrows.

Winter transects at the offsite areas revealed some interesting differences compared to the RMA (Table 4-4). Most notable were the high numbers of meadowlarks counted at Buckley (mean = 6.0 birds/1000 m, range = 2.7-10.7) and of horned larks counted at PCC (mean = 14.8 birds/1000 m, range = 9.5-20.0). Most of the differences for meadowlarks were contributed by the cheatgrass/perennial grass type (10.7 birds/1000 m at Buckley vs. 1.8 at RMA). For horned larks, most of the differences were contributed by the native perennial grass type (20.0 birds/1000 m at PCC vs. 1.6 at RMA).

4.7.2 Quantitative Breeding Surveys

Four species of nesting grassland songbirds were present in sufficient numbers to permit quantitative analyses of their habitat affinities and onsite-offsite comparisons. These were

the horned lark, western meadowlark, grasshopper sparrow, and vesper sparrow. All four of these species commonly nest in prairie habitat along the Front Range (Bailey and Niedrach 1965, Chase et al. 1982a). During the breeding season, horned larks show strong affinities for open areas with scattered low vegetation (Udvardy 1977). The western meadowlark is more generalized in its habitat requirements than the other three species (Rotenberry and Wiens 1980). The grasshopper sparrow tends to prefer tallgrass species (Rotenberry and Wiens 1981) but is commonly encountered in fields of short grasses and weeds as well (Robbins et al. 1983). The vesper sparrow is a widely distributed species (Robbins et al. 1983), and has been reported to have habitat affinities that defy generalization (Rotenberry and Wiens 1981). All four species are known to nest in Colorado throughout June and into early July (Bailey and Niedrach 1965). Additional songbirds nesting in open habitats of RMA were the lark sparrow and lark bunting.

4.7.2.1 Onsite Results

As can be seen on Table 4-5, the western meadowlark was the most common grassland songbird at RMA in 1986. Although meadowlarks were most numerous in habitats dominated by perennial grasses (crested wheatgrass, native grassland, and sand sagebrush grassland), they also occurred in weedy forb and cheatgrass/ weedy forb communities. Horned larks also occurred in both weedy and grassy habitats, especially areas with low or sparse cover. This reflects the fact that meadowlarks and horned larks are largely insectivorous, and thus less dependent on the quality and quantity of grass seed than the granivorus sparrows.

The total number of territorial males for the four species combined ranged from 1.0/ha for weedy forbs and 1.2/ha for cheatgrass/weedy forbs, to 2.0/ha for both native grassland and sand sagebrush and 2.5/ha for crested wheatgrass.

TABLE 4-5

DENSITIES AND FREQUENCIES OF NESTING SONGBIRDS AT RMA

	WF[1]		CWF		CW		NG		SB		Section 36 WF		Section 36 CWF	
	d[2]	f[3]	d	f	d	f	d	f	d	f	d	f	d	f
Western Meadowlark	0.6 (.42; 2)[4]	0.5	0.8 (.13; 2)	0.7	1.1 (.22; 2)	0.9	1.0 (.89; 3)	0.7	1.0 (1.8; 2)	0.7	1.0 (.89; 2)	0.7	1.0 (.89; 1)	1.0
Grasshopper Sparrow	0	0	0.2 (.14; 2)	0.2	1.1 (.50; 3)	0.5	0.3 (.44; 1)	0.3	0.7 (2.1; 2)	0.3	0	0	0	0
Vesper Sparrow	0	0	0.1 (.06; 1)	0.1	0.1 (.15; 1)	0.1	0	0	0.3 (1.1; 1)	0.3	0	0	0	0
Horned Lark	0.4 (.42; 2)	0.3	0.1 (.09; 2)	0.1	0.2 (.26; 2)	0.2	0.7 (.68; 2)	0.6	0	0	0.2 (.41; 1)	0.2	0	0
number of plots:	n = 12		n = 61		n = 19		n = 7		n = 3		n = 6		n = 2	

[1] WF = weedy forbs; CWF = cheatgrass with weedy forbs; CW = crested wheatgrass; NG = native grassland; SB = sand sagebrush.

[2] d = density--number of birds seen / number of plots.

[3] f = frequency--number of plots where birds were sighted / number of plots.

[4] 95 percent confidence interval on density estimate; maximum number of birds sighted within plot.

A comparison of data from Section 36 with analogous habitats in the remainder of RMA (Table 4-5) revealed no statistically significant differences. A second comparison, obtained by grouping the data into four zones ranked according to proximity to sources and presumed severity of contamination, also showed no statistically significant differences. The four zones were as follows: zone 1--section 36; zone 2--sections 26, 1, and 2; zone three = sections 35, 31, and 6; zone four--sections 30, 9, and 12. The three sections comprising zone four were randomly selected from the total number of essentially uncontaminated sections in order to keep sample sizes comparable. Data were tested by analysis of variance.

Evaluations of the onsite data suggest that grassland songbird densities were related primarily to habitat features. The importance of habitat is discussed further below.

4.7.2.2 Onsite-Offsite Comparisons

Comparing data from RMA (Table 4-5) with data from Buckley and PCC (Table 4-6) shows that grassland songbirds nested at higher densities offsite. Differences between RMA and the offsite locations (see Figure 4-9) were statistically significant, while differences between Buckley and PCC were not. This result is not surprising, because the two offsite areas were contiguous and had similar vegetation.

As shown by Figure 4-9, the pattern of abundance was nearly consistent across habitat types for all four of the species evaluated. It should be remembered that only native grassland and crested wheatgrass habitats were sampled at Buckley, and that only native grassland was sampled at PCC. The other open habitat types were not present at the offsite locations. Table 4-7 provides a comparison of densities at RMA, Buckley, and PCC by habitat type. This is also depicted in Figure 4-10.

TABLE 4-6

DENSITIES AND FREQUENCIES OF NESTING SONGIRDS OFFSITE

	BUCKLEY				PCC	
	CW[1]		NG		NG	
	d[2]	f[3]	d	f	d	f
Western Meadowlark	1.9 (.36; 3)[4]	1.0	1.6 (.28; 2)	1.0	1.6 (.22; 2)	1.0
Grasshopper Sparrow	1.6 (.45; 2)	0.9	1.0 (.55; 2)	0.6	1.8 (.36; 3)	0.9
Vesper Sparrow	0.4 (.33; 1)	0.4	0.6 (.35; 2)	0.5	0.7 (.24; 2)	0.6
Horned Lark	0.4 (.61; 3)	.02	0.9 (.46; 3)	0.7	0.9 (.23; 2)	0.7
number of plots=	n = 11		n = 15		n = 27	

1 CW = crested wheatgrass; NG = native grassland.

2 d = density--number of birds seen / number of plots.

3 f = frequency--number of plots where birds were sighted / number of plots.

4 95 percent confidence interval on density estimate; maximum number of birds sighted within plot.

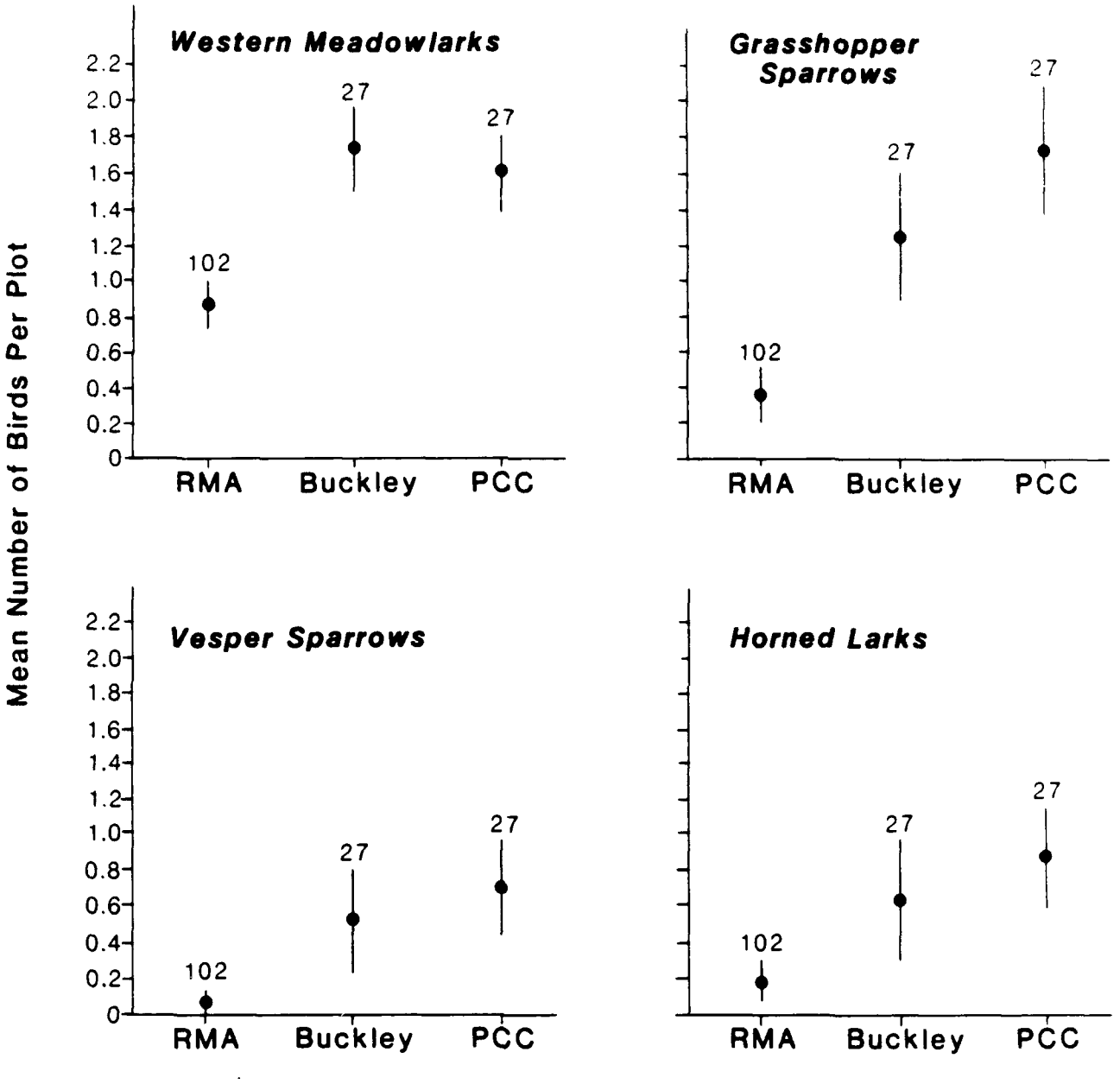


Figure 4-9. Densities of Breeding Male Birds Among Study Areas.

Note: Data are means, 95 percent confidence intervals, and sample sizes.

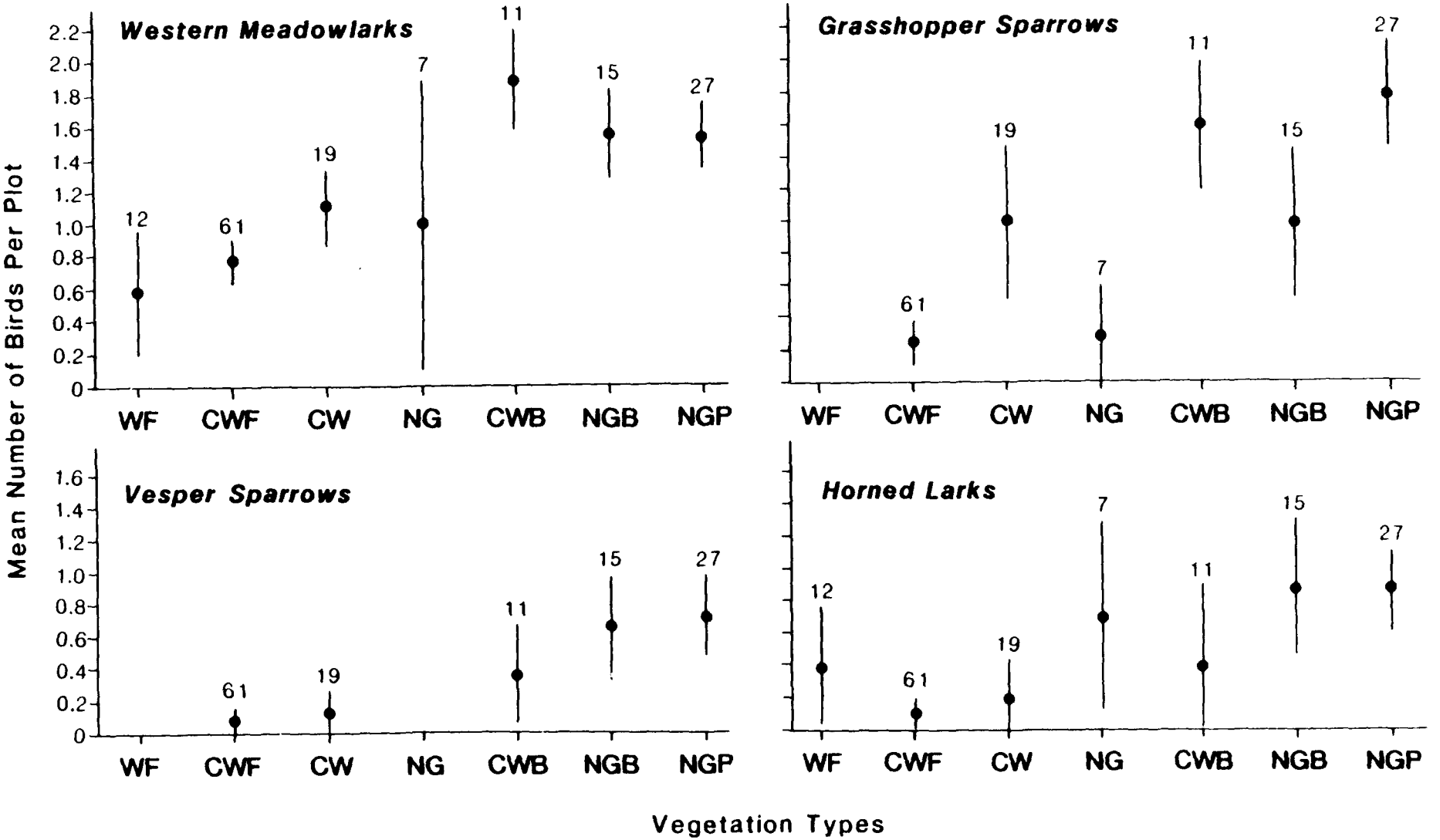


Figure 4-10. Densities of Breeding Male Birds Among Vegetation Types.

WF=weedy forbs; CWF=cheatgrass with weedy forbs; CW=crested wheatgrass; NG=native grassland; CWB=crested wheatgrass,Buckley; NGB=native grassland,Buckley; NGP=native grassland,PCC.

Note: Data are means, 95 percent confidence intervals, and sample sizes.

4.7.2.3 Key Habitat Features

Both the evaluation of onsite data and onsite-offsite comparisons both suggest that habitat was the primary factor affecting nesting densities of grassland songbirds. To address this, multiple correlation (MC) and principal component analysis (PCA) were used as a basis for determining the influence of specific habitat features.

MC seeks to identify habitat variables which, singly or in combination, most strongly influence, in this case, the habitat affinities of birds. Typically, MC reduces a large set of variables to a smaller set of useful "predictors." PCA is used to group the useful predictors into sets having an underlying interrelatedness. The major groupings of the sixteen habitat variables identified (see Section 3.7.2), as indicated by the PCA analyses, were openness, complexity, and denseness. These groupings, termed "descriptors", represent clusters of variables that have similar influences and are related biologically.

Results of the MC-PCA analyses for the four grassland songbirds are summarized in Tables 4-8 through 4-11. It should be noted that the strengths of the multiple correlations, the R^2 values (explained in the footnotes of the tables), are about equally strong for all four species. The principal component descriptor of greatest importance to all four species is complexity, which includes six of the sixteen habitat variables that were subjected to the MC-PCA analysis. All six of these habitat variables are positively correlated with bird abundance, except for one nonsignificant correlation of rabbitbrush and meadowlark density (Table 4-8). The complexity, or heterogeneity, of the vegetation therefore appears to be a key habitat feature within the three study areas. Much of the observed differences in bird abundance between the RMA and the offsite study areas (Figures 4-9 and 4-10) can be accounted for in terms of this one descriptor (see Figure 4-11).

TABLE 4-7

COMPARISON OF GRASSLAND SONGBIRD NESTING DENSITIES FOR ONSITE AND OFFSITE GRASSLAND COMMUNITIES, 1986[1]

Species	RMA		BUCKLEY		PCC
	Native Grassland	Crested Wheatgrass	Native Grassland	Crested Wheatgrass	Native Grassland
Western Meadowlark	1.0 (3)	1.1 (2)	1.6 (2)	1.9 (3)	1.6 (2)
Horned Lark	0.7 (2)	0.2 (2)	0.9 (3)	0.4 (3)	0.9 (2)
Grasshopper Sparrow	0.3 (1)	1.1 (3)	1.0 (2)	1.6 (2)	1.8 (3)
Vesper Sparrow	--	0.1 (1)	0.6 (2)	0.4 (1)	0.7 (2)
Total	2.0	2.5	4.1	4.3	5.0
Number of Plots	n = 7	n = 19	n = 15	n = 11	n = 27

1 Data are mean density (number of pairs per hectare); maximum density in parentheses.

TABLE 4-8

WESTERN MEADOWLARK HABITAT ANALYSIS. STUDY AREA INCLUDES RMA, BUCKLEY, PCC (n=156)

PRINCIPAL COMPONENT (PC) DESCRIPTOR--habitat variables	CONTRIBUTION of PC, Sr^2	STATISTICAL SIGNIFICANCE (P<0.05)
COMPLEXITY--no. of plant species (+); no. of life forms (+); cactus (+); rabbitbrush (0); warm season grasses (+); cool season grasses (+).	0.120	Sig
OPENNESS--bare soil (-); prairie dogs (0); perennial forbs (-); height of vegetation (0).	0.059	Sig
DENSENESS--total vegetation (-); cheatgrass(-); crested wheatgrass (0).	0.047	Sig
annual forbs (-).	0.015	Non Sig
sagebrush (0); interspersion (0).	0.003	Non Sig
R^2 =	0.244	Sig

Symbols in parentheses (positive, negative, or zero) refer to correlations between habitat variables and western meadowlark abundance.

Sr^2 is a measure of the unique (unshared) explanatory contribution of the principal component; it is the amount by which R^2 would be reduced if this principal component were omitted. Sr^2 is the squared semipartial correlation.

R^2 expresses the proportion of variation in the wildlife variable (western meadowlark abundance) that is predictable using the above group of principal components. R^2 is the squared multiple correlation coefficient.

TABLE 4-9

GRASSHOPPER SPARROW HABITAT ANALYSIS. STUDY AREA INCLUDES RMA, BUCKLEY, PCC (n=156)

PRINCIPAL COMPONENT (PC) DESCRIPTOR--habitat variables[1]	CONTRIBUTION of PC, Sr^2	STATISTICAL SIGNIFICANCE (P<0.05)
COMPLEXITY--no. of plant species (+); no. of life forms (+); cactus (+); rabbitbrush (+); warm season grasses (+); cool season grasses (+).	0.141	Sig
DENSENESS--total vegetation (-); cheatgrass(-); crested wheatgrass (+).	0.108	Sig
OPENNESS--bare soil (-); prairie dogs (-); perennial forbs (-); height of vegetation (0).	0.103	Sig
annual forbs (-).	0.030	Sig
sagebrush (0); interspersion (-).	0.003	Non Sig
	R^2 = 0.385	Sig

Symbols in parentheses (positive, negative, or zero) refer to correlations between habitat variables and grasshopper sparrow abundance.

Sr^2 is a measure of the unique (unshared) explanatory contribution of the principal component; it is the amount by which R^2 would be reduced if this principal component were omitted. Sr^2 is the squared semipartial correlation.

R^2 expresses the proportion of variation in the wildlife variable (grasshopper sparrow abundance) that is predictable using the above group of principal components. R^2 is the squared multiple correlation coefficient.

TABLE 4-10

VESPER SPARROW HABITAT ANALYSIS. STUDY AREA INCLUDES RMA, BUCKLEY, PCC (n=156)

PRINCIPAL COMPONENT (PC) DESCRIPTOR--habitat variables[1]	CONTRIBUTION of PC, Sr^2	STATISTICAL SIGNIFICANCE (P<0.05)
COMPLEXITY--no. of plant species (+); no. of life forms (+); cactus (+); rabbitbrush (+); warm season grasses (+); cool season grasses (+).	0.263	Sig
DENSENESS--total vegetation (-); cheatgrass(-); crested wheatgrass (0).	0.026	Sig
sagebrush (0); interspersion (0).	0.013	Non Sig
annual forbs (-).	0.007	Non Sig
OPENNESS--bare soil (0); prairie dogs (0); perennial forbs (0); height of vegetation (-).	<0.001	Non Sig
	R^2 = 0.309	Sig

Symbols in parentheses (positive, negative, or zero) refer to correlations between habitat variables and vesper sparrow abundance.

Sr^2 is a measure of the unique (unshared) explanatory contribution of the principal component; it is the amount by which R^2 would be reduced if this principal component were omitted. Sr^2 is the squared semipartial correlation.

R^2 expresses the proportion of variation in the wildlife variable (vesper sparrow abundance) that is predictable using the above group of principal components. R^2 is the squared multiple correlation coefficient.

TABLE 4-11

HORNED LARK HABITAT ANALYSIS. STUDY AREA INCLUDES RMA, BUCKLEY, PCC (n=156)

PRINCIPAL COMPONENT (PC) DESCRIPTOR--habitat variables[1]	CONTRIBUTION of PC, Sr^2	STATISTICAL SIGNIFICANCE (P<0.05)
COMPLEXITY--no. of plant species (+); no. of life forms (+); cactus (+); rabbitbrush (+); warm season grasses (+); cool season grasses (+).	0.181	Sig
OPENNESS--bare soil (0); prairie dogs (+); perennial forbs (0); height of vegetation (-).	0.045	Sig
DENSENESS--total vegetation (-); cheatgrass(-); crested wheatgrass (-).	0.033	Sig
sagebrush (0); interspersion (0).	0.002	Non Sig
annual forbs (0).	0.001	Non Sig
	R^2 = 0.262	Sig

Symbols in parentheses (positive, negative, or zero) refer to correlations between habitat variables and horned lark abundance.

Sr^2 is a measure of the unique (unshared) explanatory contribution of the principal component; it is the amount by which R^2 would be reduced if this principal component were omitted. Sr^2 is the squared semipartial correlation.

R^2 expresses the proportion of variation in the wildlife variable (horned lark abundance) that is predictable using the above group of principal components. R^2 is the squared multiple correlation coefficient.

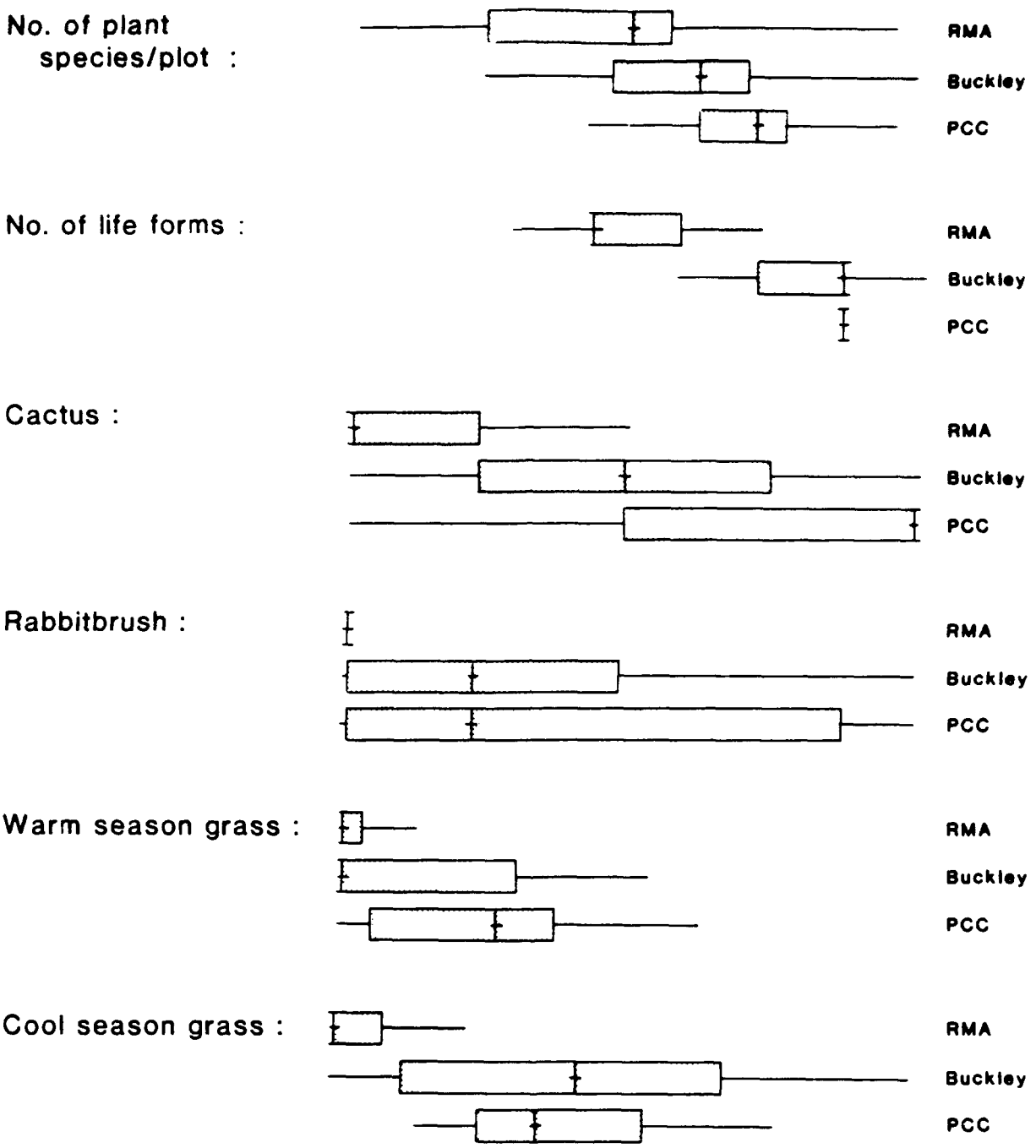


Figure 4.11. Comparison of Six Habitat Variables Among Study Areas.

Note: The six variables comprise the principal component COMPLEXITY. Each variable is plotted on a standardized scale to facilitate comparisons between study areas. Vertical lines are medians : ends of boxes are quartiles: horizontal lines approximate the range.

4.7.3 Qualitative Spring and Summer Surveys

As described above, the prevalent breeding songbirds in open habitats on the RMA were the western meadowlark, horned lark, grasshopper sparrow, vesper sparrow, and, to a lesser extent, the lark sparrow and lark bunting. The presence of other habitats such as marshes, riparian woodlands, upland groves, ornamental plantings, and abandoned buildings attracted a variety of additional bird species. Habitat affinities of these species are described below and summarized in Appendix Table A-2.

Throughout much of the southern part of the Arsenal, mature deciduous trees occur as ornamental plantings along roadsides, near buildings, or around abandoned homesteads. The small clumps or individual trees were used for nesting by northern flickers, western kingbirds, eastern kingbirds, black-billed magpies, American robins, northern mockingbirds, loggerhead shrikes, European starlings, lark sparrows, Brewer's blackbirds, common grackles, northern orioles, lesser goldfinches, house finches, and house sparrows. Most of these species fed primarily in adjacent open habitats, including grasslands, weed patches, and lawns.

Riparian woodlands and upland groves contained denser and more extensive growths of trees and more diverse understories than the ornamental plantings, and thus supported a richer avifauna. The most common nesting species in these habitats were the northern flicker, black-billed magpie, house wren, American robin, European starling, yellow warbler, chipping sparrow, and lesser goldfinch. Less common nesting species included the yellow-billed cuckoo, common nighthawk, downy woodpecker, western wood-pewee, violet-green swallow, blue jay, black-capped chickadee, gray catbird, red-eyed vireo, warbling vireo, black-headed grosbeak, blue grosbeak, indigo bunting, lazuli bunting, rufous-sided towhee, and American goldfinch.

The importance of riparian woodlands and upland groves to small birds was further evidenced by the number of species they attracted during spring migration. These included the red-headed woodpecker, dusky flycatcher, willow flycatcher, cordilleran flycatcher, tree swallow, brown creeper, white-breasted nuthatch, ruby-crowned kinglet, Swainson's thrush, hermit thrush, brown thrasher, Tennessee warbler, orange-crowned warbler, Nashville warbler, northern parula warbler, black-and-white warbler, blackburnian warbler, chestnut-sided warbler, yellow-rumped warbler, blackpoll warbler, Wilson's warbler, hooded warbler, ovenbird, northern waterthrush, American redstart, rose-breasted grosbeak, white-crowned sparrow, fox sparrow, Lincoln's sparrow, song sparrow, and pine siskin. Most of these species are regular migrants through the Front Range Urban Corridor, although some of the warblers are very uncommon. The most abundant and widespread of these migrants were yellow-rumped warblers, which along with house wrens, yellow warblers, and chipping sparrows were observed in virtually every stand of trees.

Nesting birds observed in cattail marshes along First Creek, the South Lakes, Rod and Gun Club Pond, and North Bog Pond included the red-winged blackbird, yellow-headed blackbird, common yellowthroat, and song sparrow. Migrants seen in cattails included bobolinks and marsh wrens.

Migrants observed in grasslands or open shrublands included Brewer's, clay-colored, savannah, and Cassin's sparrows, plus chestnut-collared longspurs, all in very low numbers. Abandoned buildings provided nesting habitat for rock doves (domestic pigeons), chimney swifts, Say's phoebes, barn swallows, cliff swallows, and house sparrows.

4.8 WATER BIRDS

4.8.1 Waterfowl

Waterfowl were common on the lakes and ponds at RMA during the fall and spring (Tables 4-12 and 4-13). Canada geese were one of the more abundant species observed. This species has become very abundant along the Front Range in recent years. Dabbling (surface-feeding) ducks observed included the mallard, northern pintail, gadwall, American wigeon, northern shoveler, blue-winged teal, cinnamon teal, and green-winged teal. All of these species are common on small ponds and lakes along the Front Range. Dabbling ducks observed nesting on the RMA included the mallard, gadwall, blue-winged teal, and green-winged teal.

Diving ducks regularly observed at RMA included the canvasback, redhead, ring-necked duck, lesser scaup, common goldeneye, and bufflehead. Only the redhead was observed nesting onsite. Diving ducks are usually most common on large bodies of water. The remaining ducks identified were the common merganser, hooded merganser, and ruddy duck. All three of these species were uncommon migrants. Species of grebes observed at RMA were the western (or Clark's), eared, and pied-billed. Of these, only the pied-billed grebe was observed nesting.

A comparison of the relative use of RMA lakes by waterfowl is provided in Tables 4-12 and 4-13. In comparing densities, the areal extent of each lake should be taken into account. This information is therefore provided in the tables. The tables show that Lake Ladora (25 ha) was the lake most heavily used by diving species in both spring and fall. Dabblers were more evenly distributed, although Havana Pond (8 ha) and Lake Mary (3 ha) received disproportionately high use. Lower Derby Lake (38 ha) received relatively little use by either divers or dabblers.

TABLE 4-12

WATER BIRD COUNTS ON THE RMA, SPRING 1986[1]

Species	Upper Derby (7 ha)	Lower Derby (38 ha)	Lake Ladora (25 ha)	Lake Mary (3 ha)	Havana Pond (8 ha)	North Bog (1 ha)
Pied-billed grebe	0	0.3 (2)	0.5 (5)	0.1 (1)	0	1.6 (2)
Eared grebe	0	0.2 (2)	0.1 (1)	0	0.2 (2)	0
Western grebe	0	0.9 (4)	0.9 (4)	0	0	0
Great blue heron	0.8 (5)	0.9 (4)	0.4 (1)	0.2 (1)	1.7 (4)	0.5 (2)
Canada goose	1.8 (8)	8.1 (22)	28.4 (59)	14.9 (28)	4.4 (8)	0.5 (4)
Mallard	28.6 (38)	5.2 (78)	3.7 (12)	0.5 (2)	10.4 (22)	1.2 (4)
Pintail	4.9 (14)	1.5 (20)	0.3 (4)	0	0.5 (2)	0
Gadwall	5.0 (6)	1.9 (12)	14.2 (54)	0.7 (9)	2.2 (5)	4.5 (4)
Wigeon	0.5 (2)	0.3 (2)	0.3 (4)	0	0	0
Shoveler	8.6 (26)	0	0.9 (8)	0.5 (4)	1.5 (6)	0
Blue-winged teal	2.5 (5)	0.2 (3)	0.5 (4)	0.3 (2)	2.9 (9)	1.5 (3)
Cinnamon teal	3.4 (8)	0	0	0.2 (2)	0.8 (5)	0.4 (3)
Green-winged teal	7.5 (26)	0.2 (2)	0.5 (4)	0.1 (1)	0.9 (8)	0
Canvasback	0	0.1 (2)	1.7 (14)	0.6 (6)	0.2 (3)	0
Redhead	0.5 (2)	0.6 (2)	20.9 (155)	0.2 (2)	8.1 (16)	2.9 (9)
Ring-necked duck	0	0	2.4 (18)	0.5 (7)	0	0
Lesser scaup	0	0	20.1 (220)	0.2 (2)	0.4 (5)	0.4 (4)
Bufflehead	0	0	0.1 (2)	0	0.2 (1)	0
Common merganser	0	0.5 (6)	0	0	0	0
Ruddy duck	0	0	1.5 (6)	0	0	0
American coot	0.3 (2)	4.2 (11)	29.2 (87)	7.1 (14)	0	6.9 (7)
n (number of counts) =	8	13	13	13	13	13

1 Data are mean number of birds counted per day; maximum daily counts in parentheses.

TABLE 4-13

WATER BIRD COUNTS ON THE RMA, FALL 1986[1, 2]

Species	Lower Derby (38 ha)	Lake Ladora (25 ha)	Lake Mary (3 ha)	Havana Pond (8 ha)	North Bog (1 ha)
Pied-billed grebe	0	2.3 (7)	0	0.3 (1)	1.7 (4)
Western grebe	0.3 (1)	0	0	0	0
Great blue heron	0.7 (1)	0	0	0	0
Canada goose	2.3 (7)	0	14.5 (58)	0	0
Mallard	2.3 (7)	4.8 (11)	8.5 (34)	52.0 (77)	0
Pintail	0	0	0.5 (2)	5.3 (12)	0
Gadwall	2.0 (6)	20.8 (36)	19.5 (30)	5.7 (12)	0
Wigeon	0	0.3 (1)	3.0 (7)	0.7 (2)	0
Cinnamon teal	0	0	0	0.7 (2)	0
Green-winged teal	0	0	1.0 (4)	2.7 (8)	0
Canvasback	0	0.3 (1)	0.8 (3)	0	0
Redhead	0	2.5 (9)	0.8 (3)	0	0
Ring-necked duck	0	7.5 (30)	9.0 (19)	0	0
Lesser scaup	0	0.8 (3)	1.0 (4)	4.0 (7)	0
Common goldeneye	1.3 (4)	0.5 (2)	0	0.3 (1)	0
Bufflehead	0	0.5 (2)	0	0.3 (1)	0
Coot	0	38.0 (66)	2.0 (5)	0	0
n (number of counts) =	3	4	4	3	3

[1] Data are mean number of birds counted per day; maximum daily counts in parentheses.

[2] Upper Derby Lake was dry during the survey period.

By far the greatest use by waterfowl of any RMA lake was in the spring of 1986, when 7 ha of shallow water in Upper Derby Lake held an average of 61 dabbling ducks during eight surveys (Table 4-12).

4.8.2 Wading Birds

The only wading birds observed regularly at RMA were the great blue heron and black-crowned night-heron. Great blue herons were often seen around the various lakes and ponds onsite (Tables 4-12 and 4-13), generally as solitary individuals feeding in shallow water. Great blue herons did not nest at the Arsenal, but instead may have flown in from nesting colonies at Barr Lake, 8 km northeast of the site, or along the South Platte River.

Black-crowned night-herons are smaller and more secretive than great blue herons. They are seldom seen feeding in the open, and were observed at RMA primarily in dense cattail stands near North Bog Pond, Rod and Gun Club Pond, and First Creek. In both 1986 and 1987, night-herons almost certainly nested in the mixed cottonwood/cattail wetland just north of the Toxic Storage Yard Pond in Section 31. This conclusion is based on frequent observations of two adults in the area during the breeding season, and occasional courtship behavior. However, no nest was found and no young were seen either year.

Other wading birds identified included snowy egrets, which were seen at Lower Derby Lake and North Bog Pond, and a little blue heron at Havana Pond.

4.8.3 Shorebirds, Gulls, and Other Species

Shorebirds were common along the margins of the South Lakes and Havana Pond during spring and fall migrations. Upper and Lower Derby lakes received especially heavy use, owing to their fluctuating water levels and extensive mudflats. The most commonly observed species were the killdeer, American avocet, willet, greater yellowlegs, lesser yellowlegs, long-billed dowitcher, spotted sandpiper, and least sandpiper. Other species recorded included the white-faced ibis, solitary sandpiper, stilt sandpiper, western sandpiper, pectoral sandpiper, Wilson's phalarope, and Virginia rail. Killdeers and avocets apparently breed on the RMA, although not in large numbers.

Three species of gulls were observed on the RMA. Herring gulls and ring-billed gulls were the most common species; Franklin's gulls were seen only during migration. All three gull species are common in the region. White pelicans were observed on the RMA, occasionally during spring and regularly during mid-summer. Generally from ten to twenty individuals were seen; Lower Derby Lake received the greatest use by this species. It is likely that the pelicans were from the nesting colony at Riverside Reservoir east of Greeley. Double-crested cormorants also were regularly seen during spring and summer. This species is widely distributed along lakes and rivers throughout the region.

4.9 PHEASANTS AND DOVES

4.9.1 Ring-necked Pheasants

Ring-necked pheasants were abundant on the RMA. A seasonal trend in pheasant vocalizations on the RMA is shown on Table 4-14. The last four onsite counts and the four offsite counts (also shown on Table 4-14) were timed to coincide with the peak vocalization period. The mean number of pheasant vocalizations

TABLE 4-14

SEASONAL TREND IN PHEASANT VOCALIZATION INTENSITY, 1986

Date	Study Area	Date	Study Area
	RMA:		
26 Mar	124	12 May	581
31 Mar	88	15 May	464
7 Apr	51	22 May	579
11 Apr	149	30 May	490
15 Apr	197	6 Jun	675
17 Apr	237		
22 Apr	352	Offsite Comparison Area:	
25 Apr	374		
28 Apr	461	19 May	109
1 May	266	27 May	89
6 May	610	4 Jun	110
9 May	358	13 Jun	125

(total number of vocalizations counted at 20 stations during 4 days) during this period was 552 at the RMA and 108 offsite. This difference was statistically significant ($t = 9.17$, $df = 6$, $P < 0.001$).

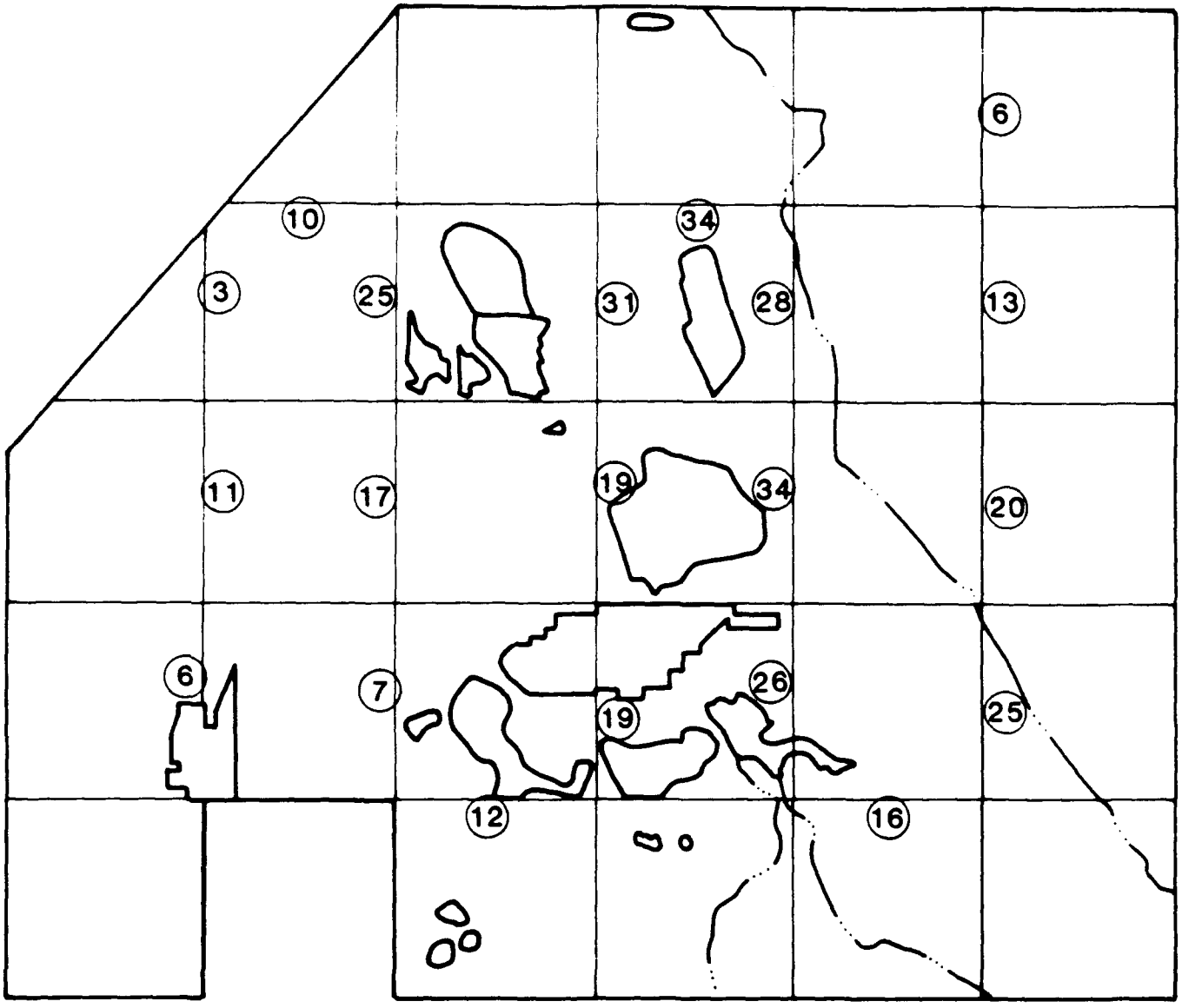
Results of the vocalization counts and fecal counts (Figures 4-12 and 4-13) show that pheasants were widespread at the Arsenal, including areas near major contamination sources. These findings are in agreement with opportunistic sightings. Analysis of habitat affinity using the fecal pellet data shown in Figure 4-13 and vegetation data from those plots, suggests a strong correlation between pheasant use and the presence of tall weedy forbs.

Male-female ratios estimated at two onsite locations were 60:38 and 20:22. Combining these samples gives a total of 80 males and 60 females, or 0.75 females per male. In hunted populations, females typically outnumber males because of resrictions on the number of hens that can be taken and the greater conspicuousness of males. Pheasants are not hunted at RMA. The reason for the large deviation from a 1:1 ratio at one of the locations is not known, but it is possible that females were undercounted because of their cryptic coloration.

4.9.2 Mourning Doves

Mourning doves were only moderately abundant at RMA. Results of three early-morning spring counts of dove vocalizations were as follows:

Number of Vocalizations	
RMA	Offsite
34	56
22	184
40	90



Note: Circled numbers represent daily means (n = 17 counts).

Rocky Mountain Arsenal

Figure 4-12.

Pheasant Vocalization Counts

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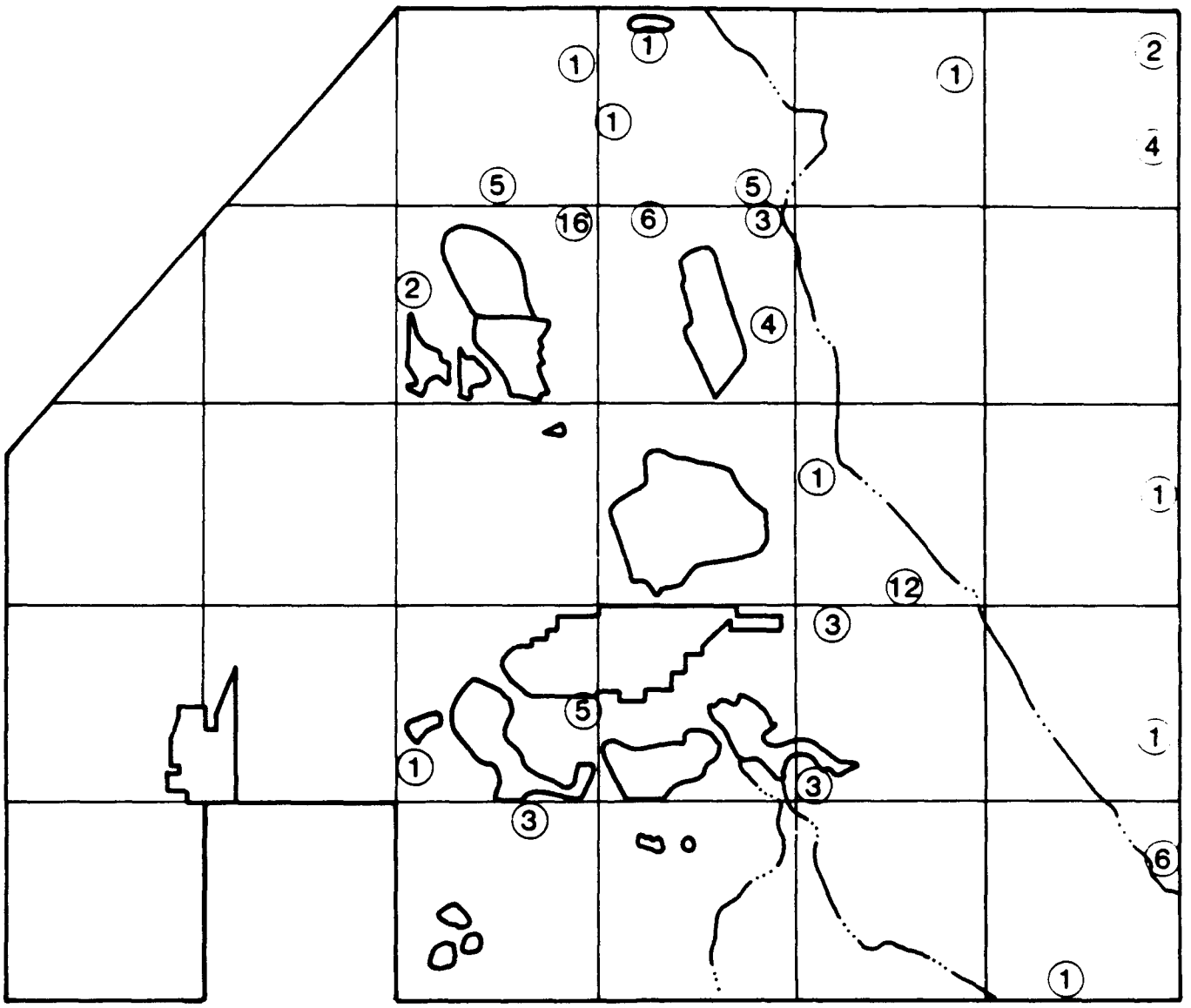


Note: Data represent number of droppings in songbird plots.

Rocky Mountain Arsenal

Figure 4-13.

Distribution of Pheasant Droppings

MORRISON-KNUDSEN ENGINEERS, INC.
A MORRISON KNUDSEN COMPANY

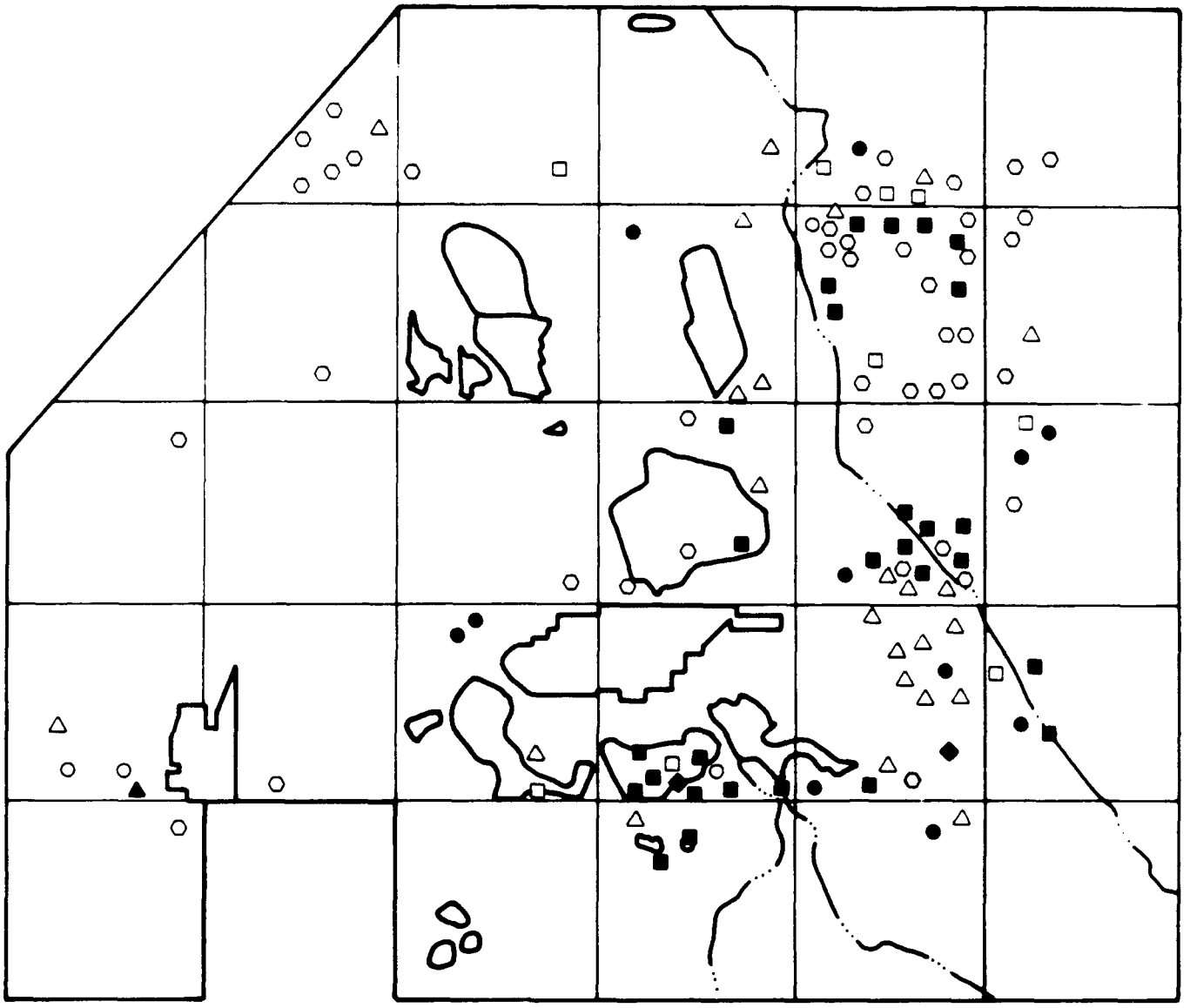
The offsite area clearly had a higher nesting population. Doves were observed nesting on the Arsenal, but not in large numbers. Also, no large concentrations of doves were seen during the late summer and fall migratory season. Doves are locally very common in the region, but apparently the RMA does not provide optimal habitat for this species.

4.10 RAPTORS

Sixteen species of raptors were identified on the RMA (see Appendix Table A-2), eleven of which were observed during formalized road surveys (Figures 4-14 through 4-16). Results of the road surveys may be used for comparing seasonal abundance, but attention must be given to the unequal number of counts. Two raptors of special concern--the bald eagle and ferruginous hawk--were found to be unusually common relative to the surrounding region. The bald eagle, federally classified as an endangered species, was observed only during the winter period. The ferruginous hawk, which is under consideration for classification as a threatened species, was present throughout the year.

Bald eagles were most commonly seen perching in the mature cottonwoods along First Creek and hunting in prairie dog towns. An intensive study of bald eagle feeding behavior and use of the First Creek roost area was conducted jointly by ESE and the FWS (ESE 1988, 1989). A comparison of Figures 4-14 and 4-16 shows that bald eagles were commonly observed along the South Lakes in 1985-86 but not in 1986-87. This difference resulted because the lakes remained free of ice much longer during 1985-86 and therefore provided hunting habitat. On one occasion, a bald eagle was observed catching a large fish at Lower Derby Lake.

Sightings of ferruginous hawks during the two winters and the intervening spring tended to cluster in the northern and eastern portions of the site. These were also the areas where prairie dog towns were most extensive (Figure 4-7). This finding, as



Note: Symbols represent sightings from seven counts.

LEGEND

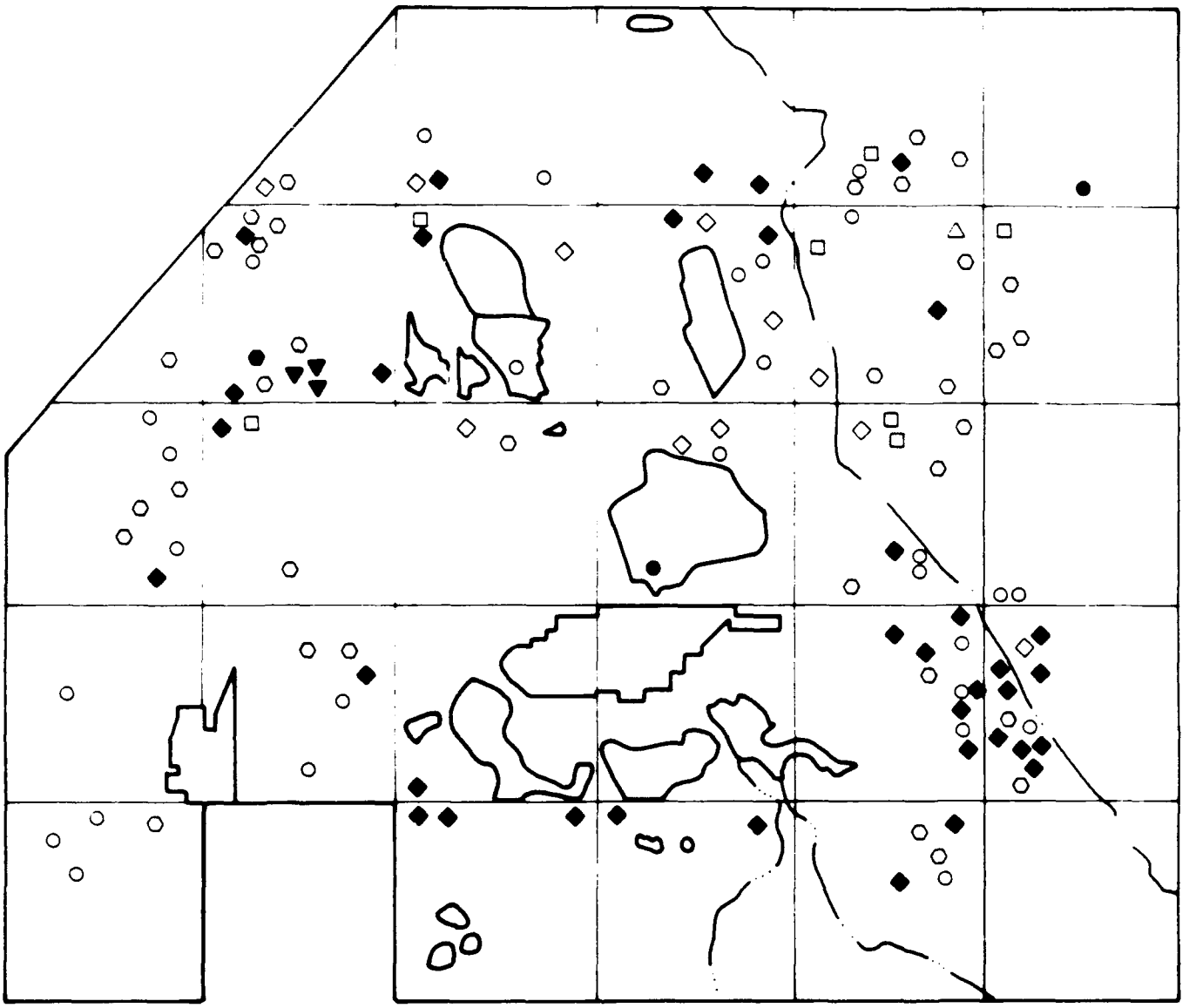
- □ Northern harrier
- ○ Red-tailed hawk
- ○ Ferruginous hawk
- △ Rough-legged hawk
- ■ Bald eagle
- ● Golden eagle
- ● Prairie falcon
- ▲ Great horned owl

Rocky Mountain Arsenal

Figure 4-14.

Raptor Roadside Counts,
Winter 1985-86

MORRISON-KNUDSEN ENGINEERS, INC.



Note: Symbols represent sightings from six counts.

LEGEND

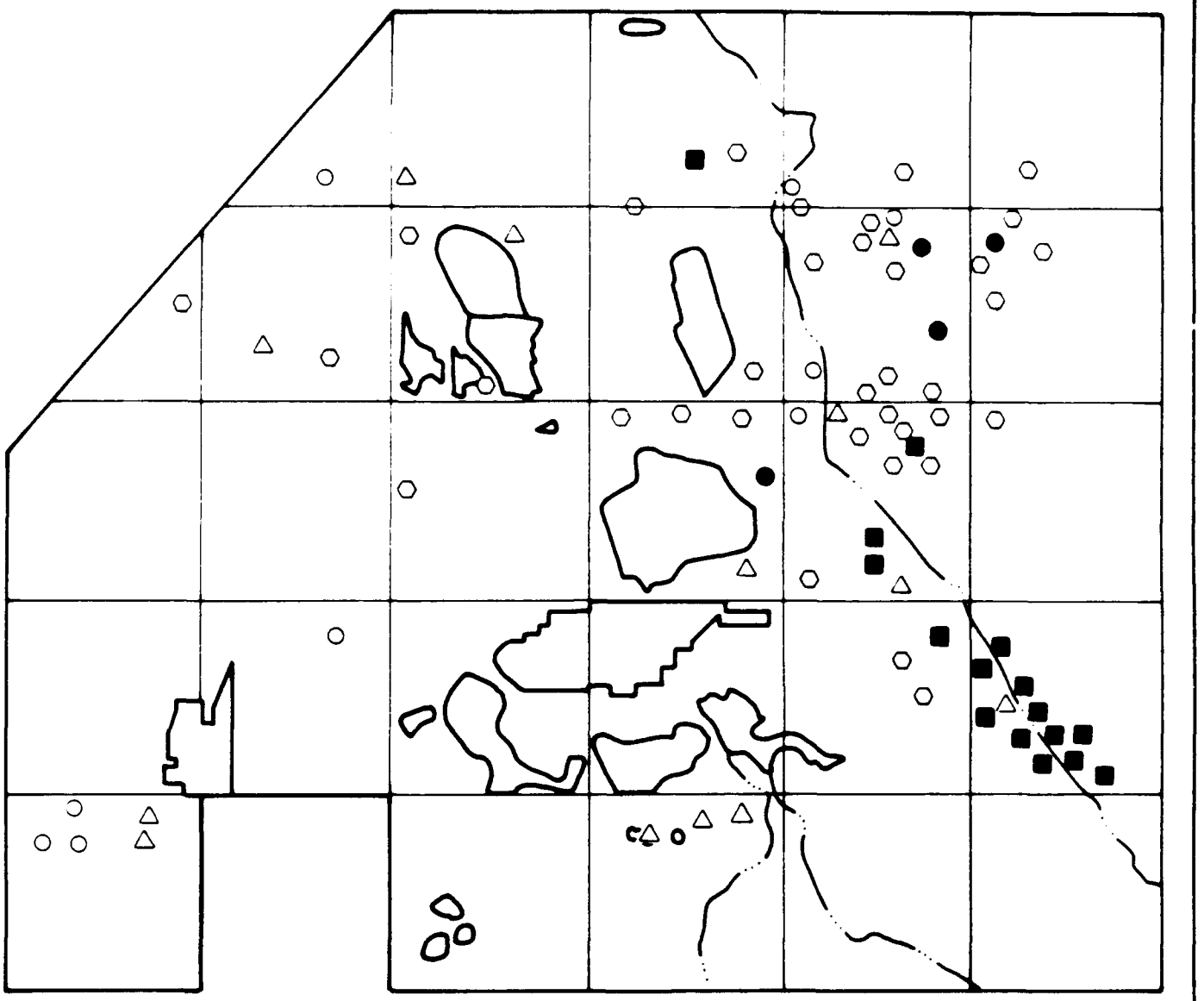
- □ Northern harrier
- ○ Red-tailed hawk
- ◇ Swainson's hawk
- ○ Ferruginous hawk
- ● Golden eagle
- ◆ American kestrel
- ● Prairie falcon
- ▼ Burrowing owl

Rocky Mountain Arsenal

Figure 4-15.

Raptor Roadside Counts,
Spring 1986

MORRISON-KNUDSEN ENGINEERS, INC



Note: Symbols represent sightings from three counts.

LEGEND

- ○ Red-tailed hawk
- ○ Ferruginous hawk
- △ Rough-legged hawk
- ■ Bald eagle
- ● Golden eagle
- ● Prairie falcon

Rocky Mountain Arsenal

Figure 4-16.

Raptor Roadside Counts,
Winter 1986-87

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well as numerous observations of ferruginous hawks hunting prairie dogs, underscores that prairie dogs were the primary prey for this species. In turn, bald eagles fed to a large extent by stealing prey from the ferruginous hawks (ESE 1988).

Red-tailed hawks, Swainson's hawks, and northern harriers were less abundant than ferruginous hawks but nonetheless were commonly seen (Figures 4-14 through 4-16). The red-tailed hawk is one of the more common hawks in the region, but only two or three individuals appeared to regularly occur on the RMA. Rough-legged hawks were common and widespread in open habitats during the winter. Cooper's hawks and sharp-shinned hawks were occasionally observed throughout the year, and always near wooded areas. Turkey vultures were present in small numbers during the summer. Golden eagles, and especially bald eagles, were common during winter. Both eagle species prey heavily on prairie dogs, cottontails, and jackrabbits. Most of the other raptors generally prefer smaller species.

Two species of falcons were observed, the American kestrel and the prairie falcon. Kestrels are common in the region and were one of the more abundant raptors on the RMA. Both falcon species consume a variety of avian and mammalian prey. Kestrels also regularly consume insects, especially grasshoppers.

Five species of owls were identified. By far the most numerous was the burrowing owl, which nested in prairie dog towns. At least twenty pairs are estimated to have nested onsite in both 1986 and 1987. Other species observed nesting on the RMA were the great horned owl and the long-eared owl. Eastern screech-owls were also observed and may have nested. These three species prefer wooded areas surrounded by open terrain, such as riparian woodlands and upland groves. A short-eared owl was observed during migration.

A comparison of raptor roadside counts between the RMA and the offsite study areas in Arapahoe and Adams counties is provided in Table 4-15. The two offsite areas, although reported by the CDOW to have large raptor populations, supported lower numbers and fewer species than the RMA during the two winters periods. The high density of raptors onsite, and the distribution pattern shown by Figures 4-14 through 4-16, indicate that raptor use at RMA is influenced primarily by habitat (perch sites, nest sites, hunting habitat, and prey base). The relatively low level of human activity at RMA has undoubtedly also been an important factor. Maps showing active raptor nests prepared by Hunter/ESE are included in the Biota RI (ESE 1989).

4.11 REPTILES AND AMPHIBIANS

As is typical of the region, relatively few species of reptiles and amphibians were present on the RMA. All species identified are discussed below. Appendix Table A-3 lists these species, as well as other "herptiles" potentially present based upon the location of RMA and the habitats present onsite.

4.11.1 Reptiles

By far the most conspicuous reptile on the RMA was the bullsnake or gopher snake. Bullsnakes were most frequently observed on roads, sunning themselves in the early morning. Many individuals over 1.5 m in length were sighted. Bullsnakes were especially abundant in the southern and western portions of the RMA but were essentially ubiquitous. The species is common throughout the region.

Other snakes regularly encountered were the western hognose snake in sandy terrain; the common gartersnake and western terrestrial gartersnake near water; and the yellow-bellied racer and plains gartersnake in a variety of habitats. Western

TABLE 4-15

RAPTOR ROADSIDE COUNTS ON THE RMA AND OFFSITE, 1986[1]

Species	WINTER 1986			SPRING 1986	
	RMA	Arapahoe County	Adams County	RMA	Adams County
Northern harrier	9	2	3	7	3
Red-tailed hawk	5	0	0	28	4
Swainson's hawk	0	0	0	11	21
Ferruginous hawk	42	0	5	35	0
Rough-legged hawk	25	4	3	0	0
Bald eagle	27	0	1	0	0
Golden eagle	10	0	0	2	0
American kestrel	0	2	0	37	11
Prairie falcon	1	0	0	1	0
Great horned owl	3	1	0	0	0
Burrowing owl	0	0	0	4	10
n (number of daily counts) =	7	3	3	6	6

1 Data are total number of sightings

rattlesnakes also were reported by personnel involved in various field activities but were not observed during wildlife studies.

Only three lizard species were seen, and these only one time each. Species observed were the lesser earless lizard and short-horned lizard in sandy soil near the South Gate, and the many-lined skink beneath a log near the edge of Upper Derby Lake. No turtles were observed, nor were they reported by other workers.

4.11.2 Amphibians

Probably the most abundant amphibian on the RMA was the northern chorus frog, which bred in large numbers in most cattail stands and in intermittently wet areas such as ditches and Upper Derby Lake. Two frog species--the northern leopard frog and the bullfrog--were seen regularly in the South Lakes, especially Lake Mary and Lake Ladora. The leopard frog was more abundant than the bullfrog, and it was also seen in other wet areas, such as North Bog Pond.

Plains spadefoot toads were occasionally seen as roadkills near Upper Derby Lake, as were both the Great Plains toad and Woodhouse's toad. All three of these species were heard chorusing in minor waterbodies or intermittently wet areas on RMA and thus are assumed to have bred onsite.

Only one tiger salamander was sighted during the wildlife study, but aquatic larvae were reported by earlier workers to be numerous in North Bog Pond.

5.0 SUMMARY AND CONCLUSION

Wildlife species identified at RMA during studies in 1986 and 1987 included essentially all the terrestrial vertebrates characteristic of similar habitats in the region. The major differences discovered through the quantitative and qualitative sampling programs were that some wildlife species were more abundant at RMA than in suitable habitats nearby, while populations of certain other species were lower. Species occurring in relatively high numbers at RMA included the mule deer, white-tailed deer, coyote, black-tailed prairie dog, ring-necked pheasant, bald eagle, ferruginous hawk, and burrowing owl.

The unusually high population of bald eagles and ferruginous hawks, along with moderately high populations of other large raptors (especially Swainson's hawks in summer and rough-legged hawks in winter) is probably related to the abundance of prey (prairie dogs, cottontails, and jackrabbits), the large expanse of suitable habitat, and a general lack of disturbance. High populations of deer and pheasants at RMA are probably due to a combination of suitable habitat and the fact that hunting is not permitted onsite. For those two species, suitable habitat includes areas of weedy forbs, which apparently provide better cover and food than native or introduced grasses.

Wildlife species found to be relatively low in abundance included various grassland songbirds, notably western meadowlarks, grasshopper sparrows, vesper sparrows, and horned larks. Offsite sampling at Buckley Air National Guard Base and the Plains Conservation Center demonstrated that grassland habitats in those areas supported higher densities of these species than were found on the Arsenal. This difference was probably related to the weediness of much of RMA and the extensive monocultures of crested wheatgrass.

Although the weediness and relatively low diversity of Arsenal grassland vegetation could have resulted from contamination in some instances, plant ecological studies by MKE (1989) indicated that most such situations are attributable to prior agricultural activities (including cultivation and intensive grazing), past use of herbicides and soil sterilants, and foraging by prairie dogs.

Offsetting the relatively poor quality of most grassland areas at RMA are (1) the habitat diversity afforded by the presence of riparian woodlands, upland groves, thickets, and ornamental plantings; (2) an abundance of surface water, particularly in the southern portion of the site; and (3) isolated areas of relict vegetation, including short-grass prairie, sand prairie, sand sagebrush, rubber rabbitbrush, and yucca. In addition, as noted above, some weedy areas provide good habitat for species such as mule deer and pheasants.

Areas of contamination and physical disturbance appear to have had relatively little adverse impact on wildlife populations, aside from the lack of habitat afforded by the basin floors and industrial complexes. Mortality of some individual organisms, apparently attributable to contaminant effects, has been documented in the Biota RI (ESE 1989). Overall, however, the diversity of habitats at RMA, together with the size and isolation of the Arsenal, has resulted in a highly productive wildlife area.

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APPENDIX A

SPECIES LISTS

TABLE A-1

MAMMALS OBSERVED OR POTENTIALLY PRESENT ON THE RMA

Species[1]	Status[2]	Abundance[3]	Habitat[4]
SORICIDAE			
Masked shrew *Sorex cinereus*	ptl	--	--
Least shrew *Cryptotis parva*	ptl	--	--
VESPERTILIONIDAE			
Small-footed myotis *Myotis leibii*	ptl	--	--
Silver-haired bat *Lasionycteris noctivagans*	ptl	--	--
Big brown bat *Eptesicus fuscus*	ptl	--	--
Hoary bat *Lasiurus cinereus*	ptl	--	--
LEPORIDAE			
Eastern cottontail *Sylvilagus floridanus*	obs	C	RW, WF
Desert cottontail *Sylvilagus audubonii*	obs	A	GL, YU, ST
Black-tailed jackrabbit *Lepus californicus*	obs	C	GL, YU, ST
White-tailed jackrabbit *Lepus townsendii*	obs	U	GL

Species[1]	Status[2]	Abundance[3]	Habitat[4]
SCIURIDAE			
Thirteen-lined ground squirrel *Spermophilus tridecemlineatus*	obs	U	GL, WF
Spotted ground squirrel *Spermophilus spilosoma*	obs	U	GL
Black-tailed prairie dog *Cynomys ludovicianus*	obs	A	GL, WF
Fox squirrel *Sciurus niger*	obs	C	RW
GEOMYIDAE			
Northern pocket gopher *Thomomys talpoides*	ptl	--	--
Plains pocket gopher *Geomys bursarius*	obs	A	GL, ST, WF
HETEROMYIDAE			
Silky pocket mouse *Perognathus flavus*	obs	U	ST, GL
Olive-backed pocket mouse *Perognathus fasciatus*	ptl	--	--
Hispid pocket mouse *Perognathus hispidus*	obs	U	ST, GL
Plains pocket mouse *Perognathus flavescens*	ptl	--	--
Ord's kangaroo rat *Dipodomys ordii*	obs	C	YU

Species[1]	Status[2]	Abundance[3]	Habitat[4]
CRICETIDAE			
Plains harvest mouse *Reithrodontomys montanus*	obs	C	WF, GL
Western harvest mouse *Reithrodontomys megalotis*	obs	C	ST
Deer mouse *Peromyscus maniculatus*	obs	A	Ubiquitous
Northern grasshopper mouse *Onychomys leucogaster*	obs	C	GL
Meadow vole *Microtus pennsylvanicus*	obs	C	CT, RW, GL
Prairie vole *Microtus ochrogaster*	obs	C	GL, RW, CT
Muskrat *Ondatra zibethicus*	obs	C	LP
ZAPODIDAE			
Meadow jumping mouse *Zapus hudsonius*	ptl	--	--
ERETHZONTIDAE			
Porcupine *Erethizon dorsatum*	ptl	--	--
CASTORIDAE			
Beaver *Castor canadensis*	ptl	--	--
MURIDAE			
Norway rat *Rattus norvegicus*	ptl	--	--
House mouse *Mus musculus*	ptl	--	--

Species[1]	Status[2]	Abundance[3]	Habitat[4]
CANIDAE			
Coycte *Canis latrans*	obs	C	Ubiquitous
Red fox *Vulpes vulpes*	obs	U	Ubiquitous
Swift fox *Vulpes velox*	(ESE 1989)	U	--
Gray fox *Urocyon cinereoargenteus*	(tracks)	U	--
PROCYONIDAE			
Raccoon *Procyon lotor*	obs	U	RW, CT
MUSTELIDAE			
Short-tailed weasel *Mustela erminea*	ptl	--	--
Long-tailed weasel *Mustela frenata*	ptl	--	--
Mink *Mustela vison*	ptl	--	--
Badger *Taxidea taxus*	obs	C	GL
Striped skunk *Mephitis mephitis*	obs	U	Ubiquitous
CERVIDAE			
Mule deer *Odocoileus hemionus*	obs	A	WF, RW, UG, ST
White-tailed deer *Odocoileus virginianus*	obs	C	RW, ST

Species[1]	Status[2]	Abundance[3]	Habitat[4]
ANTILOCAPRIDAE			
Pronghorn *Antilocapra americana*	ptl	--	--

1 Nomenclature follows Armstrong (1972)

2 Obs = observed on the RMA
Ptl = potentially present on the RMA (Armstrong 1972)

3 A = abundant, regularly present in large numbers
C = common, regularly present in moderate numbers
U = uncommon, regularly present in small numbers, or irregularly present

4 RW = riparian woodlands
LP = lakes and ponds
UG = upland groves or ornamentals
CT = cattails or wet meadows
GL = grasslands
WF = weedy forbs
ST = shrublands or thickets
YU = yucca
AB = abandoned buildings

TABLE A-2

BIRDS IDENTIFIED ON THE RMA

Species[1]	Season of Occurence[2]	Relative Abundance[3]	Habitat Preference[4]
PODICIPEDIDAE			
Pied-billed grebe *Podilymbus podiceps*	R	C	LP
Eared grebe *Podiceps nigricollis*	M	U	LP
Western grebe *Aechmophorus occidentalis*	M	U	LP
PELECANIDAE			
American white pelican *Pelecanus erythrorhynchos*	S	U	LP
PHALACROCORACIDAE			
Double-crested cormorant *Phalacrocorax auritus*	S	U	LP
ARDEIDAE			
American bittern *Botaurus lentiginosus*	S	U	CT, LP
Great blue heron *Ardea herodias*	R	U	LP
Snowy egret *Egretta thula*	M	U	LP
Little blue heron *Egretta caerulea*	M	U	LP
Black-crowned night-heron *Nycticorax nycticorax*	S	U	CT, LP

Species[1]	Season of Occurence[2]	Relative Abundance[3]	Habitat Preference[4]
THRESKIORNITHIDAE			
White-faced ibis *Plegadis chihi*	M	U	LP
ANATIDAE			
Canada goose *Branta canadensis*	R	A	LP
Green-winged teal *Anas crecca*	S	C	LP
Mallard *Anas platyrhynchos*	R	A	LP
Northern pintail *Anas acuta*	S	C	LP
Blue-winged teal *Anas discors*	S	C	LP
Cinnamon teal *Anas cyanoptera*	S	U	LP
Northern shoveler *Anas clypeata*	S	C	LP
Gadwall *Anas strepera*	R	A	LP
American wigeon *Anas americana*	R	C	LP
Canvasback *Aythya valisineria*	M	U	LP
Redhead *Aythya americana*	R	C	LP
Ring-necked duck *Aythya collaris*	M	C	LP
Lesser scaup *Aythya affinis*	M	C	LP
Common goldeneye *Bucephala clangula*	M	U	CT, LP

Shell Oil Company

c/o Holme Roberts & Owen
Suite 4100
1700 Lincoln
Denver, CO 80203

September 12, 1989

Mr. Donald L. Campbell
Office of the Program Manager
Rocky Mountain Arsenal, Building 111
ATTN: AMXRM-PM
Commerce City, CO 80022-2180

Re: United States v. Shell Oil

Dear Don:

Enclosed please find a copy of a report titled "Wildlife Resources of the Rocky Mountain Arsenal, Adams County, Colorado." The report, which presents the results of Shell/MKE wildlife investigations, was prepared within the context of "significant support" to the Biota RI. Accordingly, the Shell/MKE Wildlife Resources report represents an Other Deliverable as defined by paragraph 24.59 of the Federal Facility Agreement.

As stated in the Introduction, the purpose of the report is to provide greater detail on Shell/MKE wildlife studies than was appropriate for the Biota RI report and to present some information not included in that document. The report specifically excludes further discussion of tissue analyses, which were a joint effort between the Army/ESE and Shell/MKE and were thoroughly covered in the Biota RI report.

Reports on Aquatic Resources and Vegetation Resources of RMA will be provided during September 1989. Please let me know if you have questions.

Very truly yours,

C. K. Hahn
Manager, Denver Site Project

CKH/rw
Enc.

cc: Mr. Kevin T. Blose
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Colorado Division of Parks & Recreation
1313 Sherman Street, Room 618
Denver, CO 80203

Species[1]	Season of Occurence[2]	Relative Abundance[3]	Habitat Preference[4]
Bufflehead *Bucephala albeola*	M	U	LP
Hooded merganser *Lophodytes cucullatus*	M	U	LP
Common merganser *Mergus merganser*	M	U	LP
Ruddy duck *Oxyura jamaicensis*	M	U	LP
CATHARTIDAE			
Turkey vulture *Cathartes aura*	S	U	Ubiquitous
ACCIPITRIDAE			
Bald eagle *Haliaeetus leucocephalus*	W	C	RW, GL, WF
Northern harrier *Circus cyaneus*	R	U	GL
Sharp-shinned hawk *Accipiter striatus*	R	U	RW, UG
Cooper's hawk *Accipiter cooperii*	R	U	RW, UG
Swainson's hawk *Buteo swainsoni*	S	C	GL, UG, RW
Red-tailed hawk *Buteo jamaicensis*	S	U	RW, UG
Ferruginous hawk *Buteo regalis*	R	C	GL, WF
Rough-legged hawk *Buteo lagopus*	W	C	GL, WF
Golden eagle *Aquila chrysaetos*	W	U	GL, WF

Species[1]	Season of Occurence[2]	Relative Abundance[3]	Habitat Preference[4]
American kestrel *Falco sparverius*	S	C	GL, WF, UG, RW
Prairie falcon *Falco mexicanus*	S	U	GL, WF
CRACIDAE			
Ring-necked pheasant *Phasianus colchicus*	R	A	WF, CT, RW
RALLIDAE			
Virginia rail *Rallus limicola*	S	U	CT
Sora *Porzana carolina*	S	U	CT
American coot *Fulica americana*	R	A	LP
CHARADRIIDAE			
Killdeer *Charadrius vociferus*	S	C	LP, GL
RECURVIROSTRIDAE			
American avocet *Recurvirostra americana*	M	C	LP
SCOLOPACIDAE			
Greater yellowlegs *Tringa melanoleuca*	M	U	LP
Lesser yellowlegs *Tringa flavipes*	M	C	LP
Solitary sandpiper *Tringa solitaria*	M	U	LP

Species[1]	Season of Occurence[2]	Relative Abundance[3]	Habitat Preference[4]
Willet *Catoptrophorus semipalmatus*	M	U	LP
Spotted sandpiper *Actitis macularia*	M	C	LP
Western sandpiper *Calidris mauri*	M	U	LP
Least sandpiper *Calidris minutilla*	M	U	LP
Pectoral sandpiper *Calidris melanotos*	M	U	LP
Stilt sandpiper *Calidris himantopus*	M	U	LP
Long-billed dowitcher *Limnodromus scolopaceus*	M	U	LP
Common snipe *Gallinago gallinago*	S	U	LP, CT
Wilson's phalarope *Phalaropus tricolor*	M	C	LP
LARIDAE			
Franklin's gull *Larus pipixcan*	M	U	LP
Ring-billed gull *Larus delawarensis*	S	C	LP
Herring gull *Larus argentatus*	R	C	LP
COLUMBIDAE			
Rock dove *Columba livia*	R	U	AB
Mourning dove *Zenaida macroura*	R	C	Ubiquitous

Species[1]	Season of Occurence[2]	Relative Abundance[3]	Habitat Preference[4]
CUCULIDAE			
Yellow-billed cuckoo *Coccyzus americanus*	S	U	RW
STRIGIDAE			
Eastern screech-owl *Otus asio*	R	U	RW, UG
Great horned owl *Bubo virginianus*	R	C	RW, UG
Burrowing owl *Athene cunicularia*	S	A	GL, WF
Long-eared owl *Asio otus*	R	U	RW, UG
Short-eared owl *Asio flammeus*	W	U	GL, UG, ST
CAPRIMULGIDAE			
Common nighthawk *Chordeiles minor*	S	C	Ubiquitous
APODIDAE			
Chimney swift *Chaetura pelagica*	S	U	AB
ALCEDINIDAE			
Belted kingfisher *Ceryle alcyon*	S	U	LP
PICIDAE			
Red-headed woodpecker *Melanerpes erythrocephalus*	S	U	RW, UG
Yellow-bellied sapsucker *Sphyrapicus varius*	M	U	RW, UG

Species[1]	Season of Occurence[2]	Relative Abundance[3]	Habitat Preference[4]
Downy woodpecker *Picoides pubescens*	R	C	RW, UG
Hairy woodpecker *Picoides villosus*	W	U	RW, UG
Northern flicker *Colaptes auratus*	R	C	RW, UG
TYRANNIDAE			
Western wood-pewee *Contopus sordidulus*	S	U	RW
Willow flycatcher *Empidonax traillii*	M	U	RW
Dusky flycatcher *Empidonax oberholseri*	M	U	RW, UG
Cordilleran flycatcher *Empidonax occidentalis*	S	U	RW
Say's phoebe *Sayornis saya*	S	U	GL, AB
Western kingbird *Tyrannus verticalis*	S	A	GL, UG
Eastern kingbird *Tyrannus tyrannus*	S	C	GL, UG
ALAUDIDAE			
Horned lark *Eremophila alpestris*	R	A	GL, WF
HIRUNDINIDAE			
Tree swallow *Tachycineta bicolor*	M	U	RW
Violet-green swallow *Tachycineta thalassina*	S	U	RW
Northern rough-winged swallow *Stelgidopteryx serripennis*	S	U	RW, GL

Species[1]	Season of Occurence[2]	Relative Abundance[3]	Habitat Preference[4]
Cliff swallow *Hirundo pyrrhonota*	S	U	RW, LP
Barn swallow *Hirundo rustica*	S	C	RW, LP, AB
CORVIDAE			
Blue jay *Cyanocitta cristata*	R	U	RW, UG
Black-billed magpie *Pica pica*	R	C	RW, UG
American crow *Corvus brachyrhynchos*	R	U	Ubiquitous
PARIDAE			
Black-capped chickadee *Parus atricapillus*	R	U	RW, UG
SITTIDAE			
Red-breasted nuthatch *Sitta canadensis*	W	U	RW, UG
White-breasted nuthatch *Sitta carolinensis*	W	U	RW, UG
CERTHIIDAE			
Brown creeper *Certhia americana*	W	U	RW, UG
TROGLODYTIDAE			
House wren *Troglodytes aedon*	S	C	RW, UG
Marsh wren *Cistothorus palustris*	M	U	RW, GT

Species[1]	Season of Occurence[2]	Relative Abundance[3]	Habitat Preference[4]
MUSCICAPIDAE			
(SYLVIINAE)			
Golden-crowned kinglet *Regulus satrapa*	W	U	RW, UG
Ruby-crowned kinglet *Regulus calendula*	M	U	RW, UG
(TURDINAE)			
Mountain bluebird *Sialia currucoides*	M	U	GL, UG
Townsend's solitaire *Myadestes townsendi*	W	C	RW, UG
Swainson's thrush *Catharus ustulatus*	M	U	RW
Hermit thrush *Catharus guttatus*	M	U	RW
American robin *Turdus migratorius*	R	C	UG, RW
MIMIDAE			
Gray catbird *Dumetella carolinensis*	S	U	RW
Northern mockingbird *Mimus polyglottos*	R	U	UG, ST
Brown thrasher *Toxostoma rufum*	S	U	RW
MOTACILLIDAE			
American pipit *Anthus rufescens*	W	C	GL
BOMBYCILLIDAE			
Cedar waxwing *Bombycilla cedrorum*	W	U	UG, RW

Species[1]	Season of Occurence[2]	Relative Abundance[3]	Habitat Preference[4]
LANIIDAE			
Northern shrike *Lanius excubitor*	W	U	UG, GL
Loggerhead shrike *Lanius ludovicianus*	S	U	UG, GL
STURNIDAE			
European starling *Sturnus vulgaris*	R	C	AB, RW, UG
VIREONIDAE			
Solitary vireo *Vireo solitarius*	M	U	RW, UG
Warbling vireo *Vireo gilvus*	S	C	RW
Red-eyed vireo *Vireo olivaceus*	S	U	RW
EMBERIZIDAE			
(PARULINAE)			
Tennessee warbler *Vermivora peregrina*	M	U	RW, UG
Orange-crowned warbler *Vermivora celata*	M	C	RW, UG
Nashville warbler *Vermivora ruficapilla*	M	U	RW
Northern parula *Parula americana*	M	U	RW
Yellow warbler *Dendroica petechia*	S	C	RW, UG
Chestnut-sided warbler *Dendroica pensylvanica*	M	U	RW

Species[1]	Season of Occurence[2]	Relative Abundance[3]	Habitat Preference[4]
Yellow-rumped warbler *Dendroica coronata*	M	C	RW, UG
Blackburnian warbler *Dendroica fusca*	M	U	RW
Blackpoll warbler *Dendroica striata*	M	U	RW, UG
Black-and-white warbler *Mniotilta varia*	M	U	RW
American redstart *Setophaga ruticilla*	M	U	RW
Ovenbird *Seiurus aurocapillus*	M	U	RW
Northern waterthrush *Seiurus noveboracensis*	M	U	RW
MacGillivray's warbler *Oporornis tolmiei*	M	U	RW
Common yellowthroat *Geothlypis trichas*	S	U	CT, RW
Hooded warbler *Wilsonia citrina*	M	U	RW
Wilson's warbler *Wilsonia pusilla*	M	U	RW
Yellow-breasted chat *Icteria virens*	M	U	RW
(EMBERIZINAE)			
Rose-breasted grosbeak *Pheucticus ludovicianus*	M	U	RW, UG
Black-headed grosbeak *Pheucticus melanacephalus*	S	U	RW
Blue grosbeak *Guiraca caerulea*	S	U	UG, GL
Lazuli bunting *Passerina amoena*	S	U	RW

Species[1]	Season of Occurence[2]	Relative Abundance[3]	Habitat Preference[4]
Indigo bunting *Passerina cyanea*	S	C	RW
Dickcissel *Spiza americana*	M	U	GL
Rufous-sided towhee *Pipilo erythrophthalmus*	S	U	RW
Cassin's sparrow *Aimophila cassinii*	M	U	GL, ST
American tree sparrow *Spizella arborea*	W	A	RW, GL, WF
Chipping sparrow *Spizella passerina*	S	U	UG
Clay-colored sparrow *Spizella pallida*	M	U	WF
Brewer's sparrow *Spizella breweri*	M	U	ST
Vesper sparrow *Pooecetes gramineus*	S	C	GL, ST
Lark sparrow *Chondestes grammacus*	S	U	GL, ST, UG
Lark bunting *Calamospiza melanocorys*	S	U	GL
Savannah sparrow *Passerculus sandwichensis*	M	U	GL
Grasshopper sparrow *Ammodramus savannarum*	S	A	GL
Fox sparrow *Passerella iliaca*	M	U	RW
Song sparrow *Melospiza melodia*	R	C	RW, CT
Lincoln's sparrow *Melospiza lincolnii*	M	U	RW, CT
White-throated sparrow *Zonotrichia albicollis*	W	U	UG, WF

Species[1]	Season of Occurence[2]	Relative Abundance[3]	Habitat Preference[4]
White-crowned sparrow *Zonotrichia leucophrys*	W	C	RW, UG, WF
Harris-sparrow *Zonotrichia querula*	W	U	UG, WF
Dark-eyed junco *Junco hyemalis*	W	A	RW, UG, WF
McCown's longspur *Calcarius mccownii*	M	U	GL
Chestnut-collared longspur *Calcarius ornatus*	M	U	GL
(ICTERINAE)			
Bobolink *Dolichonyx oryzivorus*	M	U	GL, CT
Red-winged blackbird *Agelaius phoeniceus*	S	C	CT, RW
Western meadowlark *Sturnella neglecta*	R	A	GL
Yellow-headed blackbird *Xanthocephalus xanthocephalus*	S	U	CT
Brewer's blackbird *Euphagus cyanocephalus*	R	C	RW, UG, WF
Common grackle *Quiscalus quiscula*	S	C	RW, UG
Brown-headed cowbird *Molothrus ater*	S	C	RW, UG
Northern oriole *Icterus galbula*	S	C	RW, UG
FRINGILLIDAE			
House finch *Carpodacus mexicanus*	R	C	RW, UG, AB
Pine siskin *Carduelis pinus*	W	C	RW, UG

Species[1]	Season of Occurence[2]	Relative Abundance[3]	Habitat Preference[4]
Lesser goldfinch *Carduelis psaltria*	S	C	UG, WF
American goldfinch *Carduelis tristis*	S	U	UG, WF
PASSERIDAE			
House sparrow *Passer domesticus*	R	C	AB, UG

1 Nomenclature follows AOU (1983, and supplements)

2 R = Resident
M = Migrant
W = Winter
S = Summer

3 A = Abundant, regularly present in large numbers
C = Common, regularly present in moderate numbers
U = Uncommon, regularly present in small numbers, or irregularly present

4 RW = rparian woodland
UG = upland groves or ornamentals
LP = lakes and ponds
CT = cattails or wet meadows
GL = grasslands
WF = weedy forbs
ST = shrublands or thickets
YU = yucca
AB = abandoned buildings

TABLE A-3

REPTILES AND AMPHIBIANS OBSERVED OR POTENTIALLY PRESENT ON THE RMA

Species[1]	Status[2]	Abundance[3]	Habitat[4]
SNAKES			
COLUBRIDAE			
Plains garter snake *Thamnophis radix*	obs	U	ubiquitous
Common garter snake *Thamnophis sirtalis*	obs	U	moist areas
Western terrestrial garter snake *Thamnophis elegans*	obs	U	moist areas
Lined snake *Tropidoclonion lineatum*	ptl	--	--
Northern water snake *Nerodia sipedon*	ptl	--	--
Western hognose snake *Heterodon nasicus*	obs	U	sandy areas
Milk snake *Lampropeltis triangulum*	ptl	--	--
Bullsnake *Pituophis melanoleucus*	obs	C	ubiquitous
Smooth green snake *Opheodrys vernalis*	ptl	--	--
Racer *Coluber constrictor*	obs	U	ubiquitous
Coachwhip *Masticophis flagellum*	ptl	--	--
VIPERIDAE			
Western rattlesnake *Crotalus viridis*	obs	U	uplands

Species[1]	Status[2]	Abundance[3]	Habitat[4]
LIZARDS			
SCINCIDAE			
Many-lined skink *Eumeces multivirgatus*	obs	U	wooded areas
TEIIDAE			
Six-lined racerunner *Cnemidophorus sexlineatus*	ptl	--	--
IGUANIDAE			
Eastern fence lizard *Sceloporus undulatus*	ptl	--	--
Short-horned lizard *Phrynosoma douglassi*	obs	U	sandy areas
Lesser earless lizard *Holbrookia maculata*	obs	U	sandy areas
FROGS			
HYLIDAE			
Northern chorus frog *Pseudacris triseriata*	obs	A	wet areas
RANIDAE			
Bullfrog *Rana catesbyiana*	obs	C	lakes and ponds
Northern leopard frog *Rana pipiens*	obs	C	wet areas
TOADS			
PELOBATIDAE			
Plains spadefoot *Spea bobifrons*	obs	U	wet areas

Species[1]	Status[2]	Abundance[3]	Habitat[4]
BUFONIDAE			
Woodhouse's toad *Bufo woodhousei*	obs	C	wet areas
Great Plains toad *Bufo cognatus*	obs	U	wet areas
SALAMANDERS			
AMBYSTOMATIDAE			
Tiger Salamander *Ambystoma tigrinum*	obs	U	lakes and ponds
TURTLES			
TRIONYCHIDAE			
Spiny softshell *Trionyx spiniferus*	ptl	--	--
CHELYDRIDAE			
Common snapping turtle *Chelydra serpentina*	ptl	--	--
EMYDIDAE			
Western box turtle *Terrapene ornata*	ptl	--	--
Painted turtle *Chrysemys picta*	ptl	--	--

1 Nomenclature follows Smith (1978) and Smith and Brodie (1982)

2 Obs = observed on the RMA
Ptl = potentially present on the RMA (Hammerson 1986)

3 A = abundant, regularly present in large numbers
C = common, regularly present in moderate numbers
U = uncommon, regularly present in small numbers, or irregularly present

APPENDIX B

STATISTICAL INFORMATION

APPENDIX B

STATISTICAL INFORMATION

Definitions of statistical terms used in the text:

t-test - a statistical test for determining whether the difference between two sample means is statistically significant.

Analysis of variance - a statistical test for determining whether differences among three or more sample means are statistically significant.

t - the computed results of a t-test;

F - the computed results of an analysis of variance; both t and F are interpretable in terms of P.

P - the probability that the result of a statistical test is due to chance variation; if, for example, P = 0.05, then one can be 95 percent confident of a meaningful (i.e., statistically significant) difference.

df - degrees of freedom; approximately equal to the sample size.

The multiple correlation (MC) analyses used for deer, rabbits, pocket gophers, songbirds, and pheasants were conducted similarly in that the same set of independent variables (i.e., habitat variables) were used in all cases. The entire set of habitat variables used for all tests included the sixteen listed in the Methods (Section 3.7.2) plus the following six: 1) number of shrub stands (at least 10 x 10 m) within 100 m of the plot; 2) number of trees (at least 2 m tall) within 100 m of the plot; 3) sum of species cover; 4) cover by litter; 5) production of herbaceous plants; and 6) density of yucca. These six habitat variables were removed early in the data screening phase, however, because of high correlations ($r > 0.85$) with other habitat variables (i.e., they were redundant) or because they were unstable and uninterpretable in

the context of principal component analysis. Furthermore, data were screened for outliers (key-in errors or otherwise atypical data points) by examining scattergrams, and by comparing plots of leverage coefficients with standardized residuals (Sokal and Rohlf 1981). Normality was evaluated by examining probability plots (Gnanadesikan 1977); only two variables (perennial forb cover, and number of plant species) were given log transformations to correct for positive skewness. Unstable variance was evaluated by examining the pattern of residuals (Draper and Smith 1981). Following the recommendations of Tabachnick and Fidell (1983), principal components (PCA was performed only on songbird data) were restricted to eigenvalues greater than one; component loadings in excess of 0.30 were considered eligible for interpretation; and principal components defined by only one or two habitat variables were unnamed to imply uncertain underlying structure. All principal components were given varimax rotations.